NAUGATUCK RIVER BASIN
NAUGATUCK, CONNECTICUT

MULBERRY RESERVOIR DAM
CT 00130

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JANUARY 1980

UNCLASSIFIED

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Naugatuck, Conn.
Mulberry Reservoir Dam

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Mulberry Reservoir Dam consists of an earth embankment, constructed of impervious materials with a pervious zone and toe drain on the downstream side. The dam is 580 ft. in length with a top width of 20 ft, a maximum ehight of 66 ft., and upstream and downstream slopes of 2 horizontal to 1 vertical. The dam is considered to be in good condition. Taking into consideration the size and the hazard classification of "Intermediate" and "High", a test flood equal to the Probable Maximum Flood was selected in accordance with the Corps Of Engineers.

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FOUNDATIONS & MATERIALS BRANCH

R. Haestad Mfg 1/14/80

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NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS
DRAFT REPORT REVIEW COMMENTS
Mulberry Reservoir DAM, IDENTITY NO. CT00130

1/5/6 (G)

Page No.	Comments
General	(1) No page numbers
	(2) Brief Assessment mis bound
Brief Assessment	(3) Add height of dam
Section 7	(4) Par 7.2 b - add wet area on downstream slope

FOUNDATIONS & MATERIALS BRANCH

MULBERRY RESERVOIR DAM
CT 00130

NAUGATUCK RIVER BASIN
NAUGATUCK, CONNECTICUT

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

IDENTIFICATION NO: CT 00130

NAME OF DAM: Mulberry Reservoir Dam

TOWN: Naugatuck

COUNTY AND STATE: New Haven County, Connecticut

STREAM: Unnamed Tributary to the Naugatuck River

DATE OF INSPECTION: November 26, 1979

BRIEF ASSESSMENT

The Mulberry Reservoir Dam consists of an earth embankment, constructed of impervious materials with a pervious zone and toe drain on the downstream side. The dam is 580 feet in length with a top width of 20 feet, a maximum height of 66 feet, and upstream and downstream slopes of 2 horizontal to 1 vertical. A 40 foot long concrete spillway with discharge chute and stilling basin is located near the right end of the dam. The outlet works located near the center of the dam consist of a 12-inch cast iron blowoff and a 12-inch cast iron supply main through the dam, both controlled by manually operated gates located in an upstream gatehouse. The dam is classified as "Intermediate" in size, with a "High" hazard potential.

Based upon the visual inspection and a review of all available pertinent data, the dam is considered to be in good condition. The wet area downstream of the dam; the seepage into the stilling basin through joints in the bottom slab and training wall; and the vertical displacement of a portion of the bottom slab in the stilling basin require further investigation or attention.

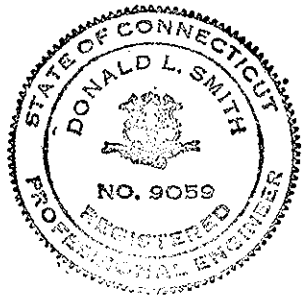
Taking into consideration the size and the hazard classifications of "Intermediate" and "High", a test flood equal to the Probable Maximum Flood (PMF) was selected in accordance with the Corps of Engineers' Guidelines. Hydraulic analyses indicate that the capacity of the existing spillway is 1600 cfs with the reservoir at elevation 574.8 (Top of Dam). The test flood inflow is 540 cfs and the routed outflow is 400 cfs, which is equivalent to a flow of water 2 feet deep over the spillway. The calculations show the spillway is capable of passing 400% of the PMF without overtopping the dam.

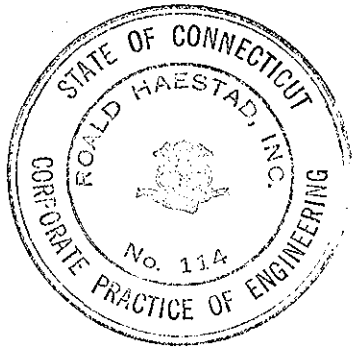
It is recommended that the owner engage the services of a qualified registered engineer experienced in the design of dams to investigate the seepage and uplift associated with the stilling basin floor slab. The significance of the wet area downstream of the dam should be investigated, and the relationship of reservoir level to flow from the toe drain should be monitored. Technical inspections of the dam should be performed by a qualified registered engineer once every two years. In addition, a formal warning system should be put into effect.

The owner should implement recommendations as described herein and in greater detail in Section 7, within two years after receipt of this Phase I Inspection Report, with the exception of the uplifting of the stilling basin floor, which should be corrected within one year.

Donald L. Smith
Project Engineer

Roald Haestad
President





PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the

condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condidtion and the downstream damage potential.

The Phase I Investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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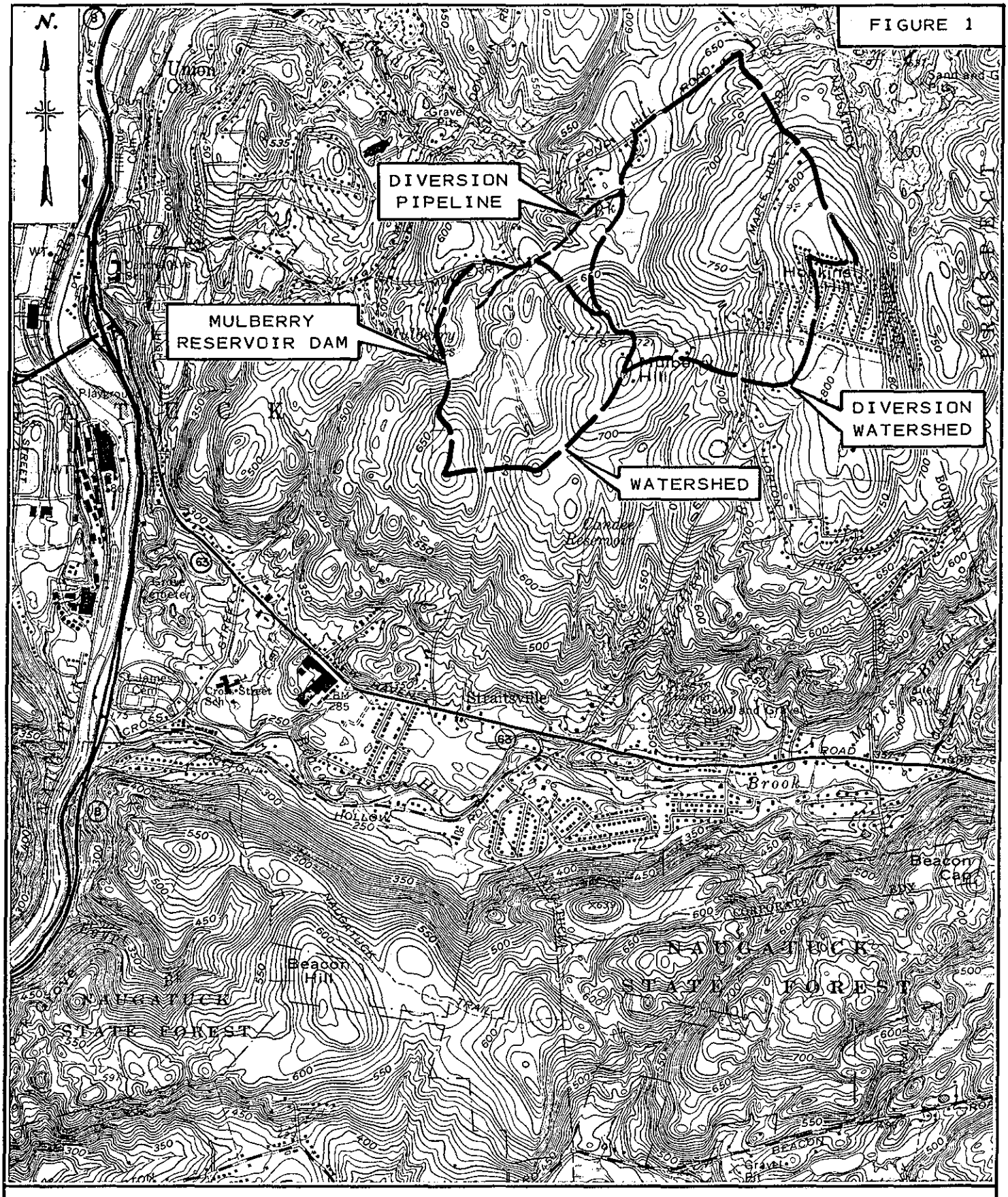
ROALD HAESTAD, INC. CONSULTING ENGINEERS WATERBURY, CONNECTICUT		

FIGURE 1



LOCATION PLAN

MULBERRY RESERVOIR DAM
NAUGATUCK, CONNECTICUT

SCALE: 1" = 2000'

ROALD HAESTAD, INC.

NAUGATUCK QUADRANGLE 1972

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

PROJECT INFORMATION
SECTION 1

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Roald Haestad, Inc., has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed were issued to Roald Haestad, Inc. under a letter of November 1, 1979, from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0015 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection

The purposes of the program are to:

1. Perform technical inspection and evaluation of non-federal dams to identify conditions requiring correction in a timely manner by non-federal interest.
2. Encourage and prepare the States to quickly initiate effective dam inspection programs for non-federal dams.
3. To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

The dam is located in the Borough of Naugatuck, Connecticut approximately one (1) mile east of the Naugatuck River. The dam is shown on the Naugatuck U.S.G.S. Quadrangle Map having coordinates latitude N 41° 29.1' and longitude W 73° 02.0'.

b. Description of Dam and Appurtenances

The Mulberry Reservoir Dam is an earth embankment with a maximum height above stream bed of 66 feet, upstream and downstream slopes of 2 horizontal to 1 vertical, and a top width of 20 feet. The present dam which was completed in the fall of 1965 was constructed immediately downstream and against an existing earth dam which had a maximum height of about 39 feet, upstream and downstream slopes of 2 horizontal to 1 vertical and a top width of 10 feet. The new embankment consists mainly of impervious materials with a pervious zone on the downstream side. A toe drain at the base of the pervious zone outlets at the stilling basin. The composition of the original embankment is unknown. The downstream slope is protected by a thick growth of grass. A stone gutter is located on a berm about mid-height on the downstream slope and discharges to the spillway channel. The upstream slope protection consists of 18 inches of 2 to 4-inch stone on a 6-inch layer of screened gravel. A 40 foot long concrete ogee spillway is located near the right abutment. The downstream spillway channel consists of a concrete chute and stilling basin. The outlet works located at the center of the dam consist of two 12-inch diameter cast iron

pipes through the dam. One is the blowoff, which outlets to the spillway channel, and the other is the intake for water supply. Both outlets are controlled by manually operated gates in the upstream gatehouse.

c. Size Classification - "Intermediate"

According to the Corps of Engineers Recommended Guidelines for Safety Inspection of Dams, a dam is classified as "Intermediate" in size if the height is between 40 and 100 feet or the dam impounds between 1,000 and 50,000 acre-feet of water. The dam has a maximum height of 66 feet and a maximum storage capacity of 205 acre-feet. Therefore, the dam is classified as "Intermediate" in size, based upon its height.

d. Hazard Classification - "High"

Based upon the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, the hazard classification of the dam is "High". Failure of the dam would cause flooding to residential homes and State highways located downstream of the dam.

e. Ownership

Former Owner: Naugatuck Water Company (which merged and became the Connecticut Water Company in 1956)

Present Owner: Connecticut Water Company
93 West Main Street
Clinton, Connecticut 06413
(203) 669-8636
Kenneth Kells, Supervisor

f. Operator: William Dunn, Division Manager
Connecticut Water Company,
Naugatuck Division
250 Meadow Street
Naugatuck, Connecticut 06770
(203) 729-8241

g. Purpose of Dam

Public water supply for the Borough of Naugatuck

h. Design and Construction History

The original Mulberry Reservoir Dam was constructed in 1897. The 302 foot long dam consisted of an earth embankment with a maximum height of 39 feet; top width of 10 feet; upsteam and downstream slopes of 2 horizontal to 1 vertical; and a 20 foot long spillway located at the left end of the dam.

In 1965, the dam was raised approximately 15 feet to its present height by W. J. Megin, Inc., of Naugatuck, Connecticut, as designed by Metcalf & Eddy, Engineers, of Boston, Massachusetts. Included in the reconstruction of the dam was the construction of a new 40 foot long concrete spillway located near the right end of the dam. The expansion joints in the spillway channel slabs have been repaired several times since the construction in 1965, most recently in August 1979.

i. Normal Operational Procedures

The Reservoir supplies water to the Mulberry Booster Pumping Station. Valves in the gatehouse are operated as required to allow water to flow to the Pump Station, which serves a portion of the Naugatuck High Service Area.

1.3 Pertinent Data

a. Drainage Area

Approximately 0.25 square miles drain directly to the Reservoir. Another 0.42 square miles is tributary via a 2,400 foot long, 18-inch diameter diversion pipeline from Hopkins Brook.

The diversion has a maximum capacity of about 30 cfs, and is controlled by a manually operated gate at its intake. The watersheds are mostly wooded, rolling hills with some residential development.

b. Discharge at Damsite

The discharge at the damsite is over a 40 foot long concrete ogee spillway. Outlet works consist of a 12-inch diameter cast iron blowoff and a 12-inch diameter cast iron supply main, originating at an upstream gatehouse and passing through the earth embankment. Both of these outlets are controlled by manually operated gates located in the gatehouse. The supply main normally discharges to a Booster Pumping Station, but piping and valves exist to allow for discharges into the stilling basin.

The maximum known discharge at the damsite occurred in January of 1979, when the Reservoir was approximately 6 inches above spillway level for an equivalent flow of 50 cfs.

1.	Outlet Works (conduits) Size:	12-inch Blowoff Pipe 12-inch Supply Line
	Invert Elevation @ Gatehouse:	Blowoff - 530.9 Supply Line - 530.6
	Discharge Capacity:	16 cfs each pipe
2.	Maximum Known Flood at Damsite:	January 1979 50 cfs
3.	Ungated Spillway Capacity at Top of Dam: Elevation:	1,600 cfs 574.8
4.	Ungated Spillway Capacity at Test Flood Elevation: Elevation:	400 cfs 571.8
5.	Gated Spillway Capacity at Normal Pool Elevation: Elevation:	N/A

6.	Gated Spillway Capacity at Test Flood Elevation: Elevation:	N/A
7.	Total Spillway Capacity at Test Flood Elevation: Elevation:	400 cfs 571.8
8.	Total Project Discharge at Top of Dam: Elevation:	1,600 cfs 574.8
9.	Total Project Discharge at Test Flood Elevation: Elevation:	400 cfs 571.8

c. Elevation - Feet Above Mean Sea Level (NGVD)

1.	Streambed at Toe of Dam:	509
2.	Bottom of Cutoff:	525
3.	Maximum Tailwater:	N/A
4.	Recreation Pool:	N/A
5.	Full Flood Control Pool:	N/A
6.	Spillway Crest:	569.8
7.	Design Surcharge - Original Design:	572.7
8.	Top of Dam:	574.8
9.	Test Flood Surcharge:	571.8

d. Reservoir - Length in Feet

1.	Normal Pool:	1,450
2.	Flood Control Pool:	N/A
3.	Spillway Crest Pool:	1,450
4.	Top of Dam:	1,500
5.	Test Flood Pool:	1,475

e. Storage - Acre-Feet

1.	Normal Pool:	145 Ac.-Ft.
2.	Flood Control Pool:	N/A
3.	Spillway Crest Pool:	145 Ac.-Ft.
4.	Top of Dam:	205 Ac.-Ft.
5.	Test Flood Pool:	170 Ac.-Ft.

f. Reservoir Surface - Acres

1.	Normal Pool:	11 acres
2.	Flood Control Pool:	N/A
3.	Spillway Crest:	11 acres
4.	Test Flood Pool:	12 acres
5.	Top of Dam:	13 acres

g. Dam

1.	Type:	Earth Embankment
2.	Length:	580'
3.	Height	66'
4.	Top Width:	20'
5.	Side Slopes:	2:1 U.S. & D.S.
6.	Zoning:	Impervious embankment with downstream pervious zone and toe drain
7.	Impervious Core:	N/A
8.	Cutoff:	Cutoff trench of impervious embankment material, 10' wide, 5' deep, with 1:1 side slopes
9.	Grout Curtain:	None
10.	Other:	

h. Diversion and Regulating Tunnel

1. Type:	N/A
2. Length:	N/A
3. Closure:	N/A
4. Access:	N/A
5. Regulating Facilities:	N/A

i. Spillway

1. Type:	Concrete ogee with concrete discharge chute and stilling basin
2. Length of Weir:	40'
3. Crest Elevation with Flashboards: without Flashboards:	 N/A 569.8'
4. Gates:	N/A
5. Upstream Channel:	N/A
6. Downstream Channel:	Concrete chute constructed on 8 inches of gravel and keyed into undisturbed soil
7. General:	

j. Regulating Outlets

1. Invert at Gatehouse:	Blowoff: 530.9 Supply Line: 530.6
2. Size:	Both 12 inches in diameter
3. Description:	Both Cast Iron
4. Control Mechanism:	Manually operated gates located in upstream gatehouse
5. Other:	Supply line can also discharge to stilling basin Capacity - 16 cfs each

ENGINEERING DATA
SECTION 2

2.1 Design Data

Available information which was reviewed included a set of Contract Plans and Specifications for raising Mulberry Dam, and also a set of hydrologic and hydraulic calculations for sizing the spillway. This information was prepared by Metcalf & Eddy, Engineers. Other design information was not readily available from either the Connecticut Water Company, or Metcalf & Eddy. No information on the original design is known to exist.

2.2 Construction Data

The Mulberry Reservoir Dam was originally constructed in 1897, and reconstructed in 1965, in order to increase the capacity of the Reservoir. Shop drawings and photographs of the reconstruction are on file at the Connecticut Water Company's Naugatuck office. There was no other available information concerning the construction of the dam.

2.3 Operation Data

The lowest lake level was recorded at 12.4 feet below the spillway on November 15, 1973, and the highest known flood flow was 0.5 feet over the spillway in January of 1979.

2.4 Evaluation of Data

a. Availability

Existing data was provided by the State of Connecticut, Department of Environmental Protection, and the Connecticut Water Company. A list of reference material available is given in Appendix B.

b. Adequacy

The information which was available, along with the visual inspection, past performance history, and hydrologic and hydraulic calculations were adequate to assess the condition of the facility.

c. Validity

Field inspections and surveys revealed that the dam was constructed substantially as shown on the plans. The dike which forms a diversion channel and the pipe installed at the left end of the dam (See Figure 2, Appendix B) to divert an area of undesirable water quality away from the reservoir are not shown on the construction plans.

VISUAL INSPECTION

SECTION 3

3.1 Findings

a. General

The visual inspection of the dam was conducted on November 26, 1979. The inspection team was accompanied by Mr. Kenneth Kells of the Connecticut Water Company. The reservoir was approximately 5 feet below spillway level. The general condition of the dam at the time of inspection was good.

b. Dam

The dam is an earth embankment with outlet works at about the center of the dam and a concrete spillway near the right abutment.

The upstream slope is covered with a layer of 2 to 4-inch crushed stone riprap which was placed on a gravel filter layer. Both materials were exposed at the crest, Photos 1 and 2. The riprap is in good condition, and only minor downstream displacements could be observed near the crest, probably due to trespassing.

The crest was mostly grass covered and did not show any visual indications of erosion or settlement. The downstream slope is grass covered and has a "stone gutter" berm 23 feet below the crest. The downstream slope shows no indications of sloughing, erosion, or seepage with the exception of a small area immediately above the berm and about 100 feet to the left of the spillway wall, where minor surface erosion has affected adversely the growth of grass, Photo 3.

Downstream of the dam there is a wet area extending from the toe to about 60 feet downstream of the toe, and between the left spillway wall and approximately 90 feet to the left of the spillway. The wet area is soft and spongy with marsh-type vegetation. Water covers most of the wet area, and no obvious flow can be observed. The water contains rust-colored floccules and occasionally an oily sheen at the surface. The wet area can be seen in Photo 4, where it can be identified by the brownish vegetation cover.

c. Appurtenant Structures

The bridge to the gatehouse is generally in good condition, except for a transverse crack at the second pier from the dam, Photo 5. The visible part of the gatehouse structure is in good condition.

The spillway is a concrete structure near the right abutment with a concrete chute and a stilling basin at the toe of the dam, Photo 6. The training walls are generally in good condition. A differential lateral movement of about 3/4 inch was observed across a construction joint in the left training wall at the crest of the dam, Photo 7. The owner's representative stated that the displacement has been observed for many years and that no change has been detected. Seepage was observed at the base of a construction joint of the left training wall at the upstream end of the stilling basin, Photo 8. The spillway floor shows repairs to the joint filler which, according to the owner's representative, have been made at different times. The floor slab of the stilling basin

shows some differential vertical movements across some construction joints, and an upward flow of water could be observed through one joint, Photo 9. The bridge across the spillway is in good condition.

A 6-inch diameter V.T. pipe and two 12-inch diameter C.I. pipes discharge into the stilling basin, Photo 10. The 6-inch pipe is the outlet for the toe drain for the dam and was discharging about 6 gallons per minute of clear water. The two 12-inch pipes were not discharging. One is the blowoff outlet, and the other is connected to the supply main. Minor cracking and efflorescence was observed in the training wall in the area of the discharge of these pipes.

d. Reservoir Area

There are no indications of instability along the edges of the reservoir in the vicinity of the dam. At the left abutment a small dike forms a channel for diversion of a drainage area with poor water quality away from the reservoir and into a 24-inch pipe with an invert elevation of 571.2 or 1.4 feet above spillway level. The pipe passes through the dam and exits to the ditch on the left of the gravel access road as a 12-inch diameter pipe (See Figure 2, Appendix B).

e. Downstream Channel

The downstream channel for the spillway and blowoff outlet is the natural streambed. Within 60 feet of the stilling basin, the bottom and banks of the channel are protected with 36-inch riprap.

3.2 Evaluation

On the basis of the visual inspection and a review of design and construction data, the dam is judged to be in good condition.

The lack of seepage out of the downstream slope indicates that the pervious shell shown in the drawings is draining embankment seepage into the drain as intended. On the other hand, the wet area downstream of the dam indicates that foundation seepage is, at least partially, passing under the toe drain and exiting downstream of the dam. Since no soil movement was observed in the wet area, this seepage does not constitute an unsafe condition at present. However, investigations are required to determine whether this condition could lead to erosion and piping in the future. The flow observed out of the toe drain of about 6 gallons per minute indicates the presence of fairly pervious soils, probably in the foundation rather than in the embankment.

The seepage into the stilling basin, both through joints in the bottom slab and in the training wall, indicates lack of appropriate drainage behind the walls and under the bottom slab. Uplift pressures under the bottom slab have apparently caused some vertical movements of the slab and further deterioration is likely to occur in the future. The design drawings indicate a transverse drainage pipe under the bottom at the downstream end of the stilling basin. No other drainage is indicated under the stilling basin.

OPERATIONAL AND MAINTENANCE PROCEDURES

SECTION 4

4.1 Operational Procedures

a. General

An operational and maintenance manual for Mulberry Reservoir has been prepared by the Connecticut Water Company, a copy of which is included in Appendix B. The reservoir provides water for the Mulberry Booster Pump Station which serves approximately 43 percent of the high service area of Naugatuck. Water from the reservoir flows through one of five intake gate valves at varying elevations, into the gate house, through the screens and exits via a 12-inch diameter supply main. Intake valving is operated as required, depending on the reservoir level and water quality.

The reservoir is patrolled daily at various hours, and checks of the following are made:

1) Spillway for debris and obstacles
2) Stream and pipe from Hopkins diversion
3) Any unusual activities, e.g., motorcycles, horseback riders, dead animals, animal burrows, etc.

In addition to the patrolman, the pump station attendant inspects and maintains aeration equipment at the reservoir.

Regular inspections of the embankments and appurtenances are made by Connecticut Water Company personnel.

b. Description of Any Warning System In Effect

There is no formal warning system in effect.

4.2 Maintenance Procedures

a. General

Normal seasonal maintenance is done as required. Tree growth is closely monitored in the area surrounding the dam, and is not allowed to encroach upon the earth embankment portions of the dam. The expansion joints in the spillway slab have been repaired four times since the dam was constructed. Monitoring and maintenance of these joints is continuing.

b. Operating Facilities

Twice a year, the intake chamber is drained and the reservoir screens cleaned. The intake to the Hopkins Brook Diversion is also cleaned twice a year.

4.3 Evaluation

The present operation and maintenance procedures are satisfactory and should remain in effect. Current visual inspections of the dam should continue on a regular basis, as should the monitoring and maintenance of spillway expansion joints.

A formal warning system should be put into effect, and should include monitoring of the dam during extremely heavy rains, and procedures for notifying downstream authorities in the event of an emergency.

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

SECTION 5

5.1 General

The spillway for Mulberry Reservoir consists of a 40 foot long concrete ogee section 5 feet below top of dam. The spillway channel consists of a concrete chute which discharges below the toe of the dam. The dam has a tributary watershed of 0.25 square miles, with an additional 0.42 square miles tributary via an 18-inch diversion pipeline. The capacity of the diversion pipeline is 30 cfs, which is small compared to the flood flows. The watershed area is mostly rolling, wooded hills, with some residential development. The Water Company owns most of the watershed.

A pipe passes through the dam near the left abutment, the upstream end being 24-inches in diameter with an invert 1.4 feet above spillway elevation. The pipe exits to the ditch on the left of the gravel access road as a 12-inch diameter pipe. A dike with a crest height 4.5 feet above the spillway separates the reservoir from the pipe. The pipe is used to divert a drainage area with poor water quality away from the reservoir.

5.2 Design Data

Hydraulic and hydrologic design data were reviewed and found adequate. The spillway was designed for a maximum discharge of 575 cfs with 2.1 feet of freeboard. Details are in Appendix B.

5.3 Experience Data

The highest known flow over the spillway occurred in January 1979, when a depth of 6 inches was recorded. This amounts to a flow of 50 cfs. The old reservoir was below spillway in 1955, and did not fill during that flood period.

5.4 Test Flood Analysis

The presence of four residential homes and two important State Highways downstream of the dam caused it to be classified as "High Potential Hazard". A test flood equal to the PMF was calculated using a peak runoff of 2150 cubic feet per second per square mile (csm) from the guide curves supplied by the Corps of Engineers for "rolling" terrain. The minimum square mile drainage area given by the curve was used. The reservoir was assumed to be at spillway level. The PMF inflow into the reservoir is 540 cfs and the routed outflow is 400 cfs.

The flood routing through the reservoir was done in accordance with "Estimating Effect of Surcharge Storage on Maximum Probable Discharges" provided by the Corps of Engineers.

The capacity of the diversion pipeline was not included in the PMF calculation as it was considered to have a negligible effect. The spillway capacity at the top of the dam is 1600 cfs, or 400% of the PMF.

Spillway capacity at the top of the dike, 0.5 feet below top of dam, would be 1350 cfs, or 338% of the PMF.

There appears to be no potential for overtopping this dam.

5.5 Dam Failure Analysis

A dam failure analysis was made using the "Rule of Thumb" guidance provided by the Corps of Engineers. Failure was assumed to occur with the reservoir at maximum elevation due to the PMF, which is 2 feet above spillway level.

A failure of this type would release up to 70,000 cfs into the valley below the dam. The nearest residential homes are along Route 63 about 5,000 feet downstream. Calculations indicate the flow would be around 14,000 cfs in this location, which would result in a flow approximately 4 feet deep near three of the houses and over Connecticut Route 63. Connecticut Route 8 is another 2,000 feet downstream and will be overtopped by about 2 feet.

The flood areas resulting from a dam breach are shown on Figure 5 in Appendix D.

EVALUATION OF STRUCTURAL STABILITY
SECTION 6

6.1 Visual Observations

The visual inspection did not disclose any evidence of present structural instability.

6.2 Design and Construction Data

The design and construction data that was available included construction plans and specifications, shop drawings, and construction photographs. Adequate information is not available to permit an in-depth stability analysis of the dam.

6.3 Post-Construction Changes

No changes are known to have occurred since the completion of the dam in 1965 which might jeopardize the safety of the dam.

6.4 Seismic Stability

The dam is located in Seismic Zone 1 and in accordance with the recommended Phase I inspection guidelines does not warrant seismic stability analysis.

ASSESSMENT, RECOMMENDATIONS & REMEDIAL MEASURES

SECTION 7

7.1 Dam Assessment

a. Condition

On the basis of the visual inspection and a review of available data, the dam is judged to be in good condition. The future safety of the dam could be affected by further deterioration of the stilling basin floor and possibly by seepage in a wet area downstream of the dam.

b. Adequacy of Information

The information available was sufficient for performing a Phase I Inspection.

c. Urgency

The recommendations presented in Sections 7.2 and 7.3 should be carried out within two years of receipt of this Report by the owner, with the exception of the modifications to the stilling basin floor slab, which should be carried out within one year.

7.2 Recommendations

The following recommendations should be carried out under the direction of a qualified registered engineer:

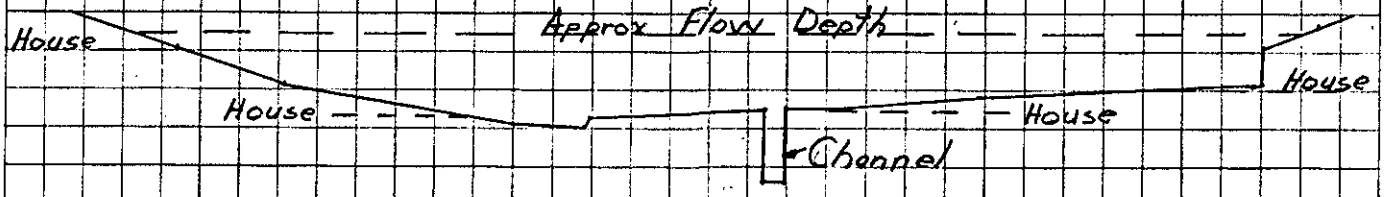
a) Design and construct modifications to the stilling basin floor slab to prevent the development of uplift water pressure.

b) Investigate the significance of the wet area downstream of the dam and recommend measures for monitoring the volume of flow out of the toe drain in relation to the reservoir level. A substantial increase or decrease in flow in a short period of time, unrelated to reservoir level, could indicate a potential problem. Monitoring should be done at least monthly for a period of two years and then the monitoring program should be adjusted based on the results of observations made. Measures for preventing possible piping and erosion problems should also be recommended if deemed necessary.

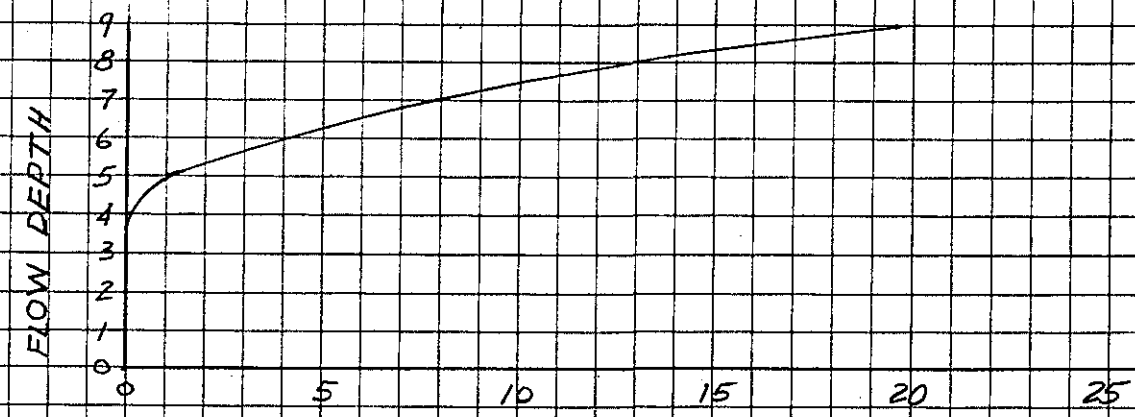
SUBJECT MULBERRY - Flood Routing

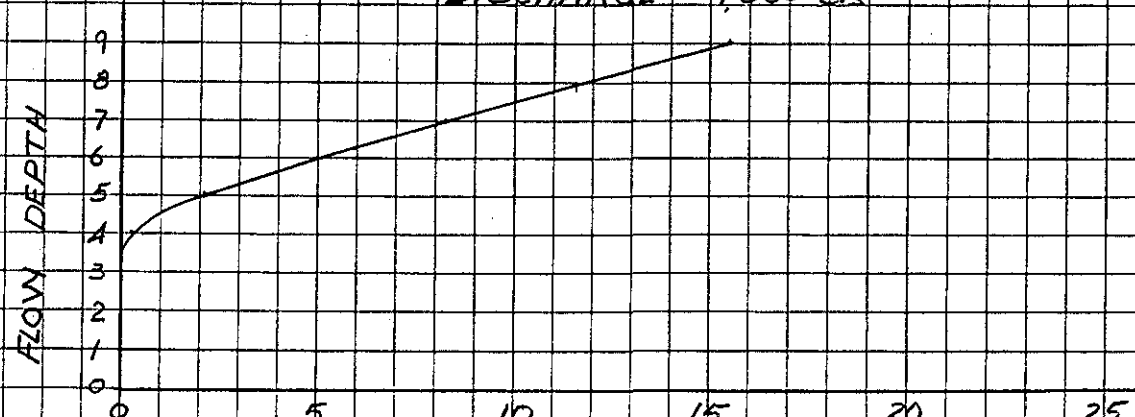
SECTION NO 5 (Field Surveyed) Scale 1" = 60' Horiz
1" = 10' Vert

L = 750 ft n = 0.05 s = 0.023



D	W_P	A	R	S	V	Q
4	45	30	0.67	0.023	3.46	104
5	185	211	1.14	0.023	4.93	1040
7	267	825	3.09	0.023	9.59	7,912
9	334	1,556	4.66	0.023	12.61	19,621





APPENDIX A

VISUAL CHECK LIST WITH COMMENTS

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT: Mulberry Reservoir Dam

DATE: 11/26/79 TIME: 10:30 a.m. to 1:00 p.m. WEATHER: Cloudy, with rain

U.S. ELEVATION: 564.8 U.S. N/A DN.S

PARTY	DISCIPLINE
Donald L. Smith, P.E. - Roald Haestad, Inc.	Civil/Hydrologist
Ronald G. Litke, P.E. - Roald Haestad, Inc.	Civil Engineer
Gonzalo Castro, Ph.D., P.E. - Geotechnical Engineers Inc.	Geotechnical Engineer
Kenneth Kells, P.E. - Connecticut Water Co.	Owner's Engineer

PROJECT FEATURE	INSPECTED BY	REMARKS
Dam Embankment	GC	Good
Dike Embankment	GC	Good
Outlet Works - Intake Channel		None observed
Outlet Works - Transition & Conduit		None observed
Outlet Works - Outlet & Channel		None observed
Outlet Works - (Gatehouse) Control Tower	GC DLS,RGL	Good
Outlet Works - Spill. Weir, App. & Disc.	GC RGL,DLS	Good with exception of uplift in stilling basin
Service Bridges	RGL,DLS	Good

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam DATE: 11/26/79

PROJECT FEATURE: Dam Embankment NAME: RGL, DLS

DISCIPLINE: Geotechnical Engineer - Civil Engineer NAME: GC

AREA ELEVATION	CONDITIONS
DAM EMBANKMENT	
CREST ELEVATION	574.8'
CURRENT POOL ELEVATION	564.8' - 5 feet below spillway
MAXIMUM IMPOUNDMENT TO DATE	Approx. 6" above spillway level
SURFACE CRACKS	None observed
PAVEMENT CONDITION	N/A
MOVEMENT OR SETTLEMENT OF CREST	None observed
LATERAL MOVEMENT	None observed
VERTICAL ALIGNMENT	Good
HORIZONTAL ALIGNMENT	Good
CONDITION AT ABUTMENT AND AT CONCRETE STRUCTURES	Good
INDICATIONS OF MOVEMENT OF STRUCTURAL ITEMS ON SLOPES	Pier for gatehouse bridge cracked, but no apparent movement of pier foundation.
TRESPASSING ON SLOPES	None of significance
VEGETATION ON SLOPES	Grass covered crest, downstream slope
SLOUGHING OR EROSION OF SLOPES OR ABUTMENTS	Slight undulations of downstream slope, but no apparent sloughing
ROCK SLOPE PROTECTION - RIPRAP FAILURES	Good condition
UNUSUAL MOVEMENT OR CRACKING AT OR NEAR TOES	None observed
UNUSUAL EMBANKMENT OR DOWNSTREAM SEEPAGE	Wet area downstream of dam, left of spillway. Rust-stained water. No observable movement.
PIPING OR BOILS	None observed
FOUNDATION DRAINAGE FEATURES	None known or observed
TOE DRAINS	Toe drains. Discharges about 6 gallons per minute.
INSTRUMENTATION SYSTEM	None known

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam DATE: 11/26/79

PROJECT FEATURE: Dike Embankment NAME: RGL, DLS

DISCIPLINE: Geotechnical Engineer - Civil Engineer NAME: GC

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	
CREST ELEVATION	Dike at left abutment to divert surface runoff away from reservoir.
CURRENT POOL ELEVATION	Dike fully above water at time of inspection
MAXIMUM IMPOUNDMENT TO DATE	Approx. 6" above spillway level
SURFACE CRACKS	None observed
PAVEMENT CONDITION	N/A
MOVEMENT OR SETTLEMENT OF CREST	Too irregular to judge
LATERAL MOVEMENT	Too irregular to judge
VERTICAL ALIGNMENT	Too irregular to judge
HORIZONTAL ALIGNMENT	Too irregular to judge
CONDITIONS AT ABUTMENT AND AT CONCRETE STRUCTURES	N/A
INDICATIONS OF MOVEMENT OF STRUCTURAL ITEMS ON SLOPES	N/A
TRESPASSING ON SLOPES	None observed
VEGETATION ON SLOPES	Heavy growth of bushes and small trees
SLOUGHING OR EROSION OF SLOPES OR ABUTMENTS	None observed
ROCK SLOPE PROTECTION - RIPRAP FAILURE	None observed
UNUSUAL MOVEMENT OR CRACKING AT OR NEAR TOES	None observed
UNUSUAL EMBANKMENT OR DOWNSTREAM SEEPAGE	None observed (Dike fully above water)
PIPING OR BOILS	None observed (Dike fully above water)
FOUNDATION DRAINAGE FEATURES	None known
TOE DRAINS	None
INSTRUMENTATION SYSTEM	None known

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam DATE: 11/26/79

PROJECT FEATURE: Outlet Works - Intake Channel and Structure NAME:

DISCIPLINE: Geotechnical Engineer NAME: GC

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
A. APPROACH CHANNEL:	None observed
SLOPE CONDITIONS	
BOTTOM CONDITIONS	
ROCK SLIDES OR FALLS	
LOG BOOM	
DEBRIS	
CONDITION OF CONCRETE LINING	
DRAINS OR WEEP HOLES	
B. INTAKE STRUCTURE:	None observed
CONDITION OF CONCRETE	
STOP LOGS AND SLOTS	

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam DATE: 11/26/79

PROJECT FEATURE: Outlet Works - Transition and Conduit NAME: DLS

DISCIPLINE: Civil Engineer NAME: RGL

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	
GENERAL CONDITION OF CONCRETE	N/A
RUST OR STAINING ON CONCRETE	N/A
SPALLING	N/A
EROSION OR CAVITATION	N/A
CRACKING	N/A
ALIGNMENT OF MONOLITHS	N/A
ALIGNMENT OF JOINTS	N/A
NUMBERING OF MONOLITHS	N/A

GENERAL: Outlet works conduit consists of 2 - 12-inch cast iron pipes through the dam. Pipes were not observed.

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam DATE: 11/26/79

PROJECT FEATURE: Outlet Works - Outlet Structure and Channel NAME: RGL

DISCIPLINE: Civil Engineer NAME: DLS

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	No outlet structure and channel
GENERAL CONDITION OF CONCRETE	N/A
RUST OR STAINING	N/A
SPALLING	N/A
EROSION OR CAVITATION	N/A
VISIBLE REINFORCING	N/A
ANY SEEPAGE OR EFFLORESCENCE	N/A
CONDITION AT JOINTS	N/A
DRAIN HOLES	N/A
CHANNEL	N/A
LOOSE ROCK OR TREES OVERHANGING CHANNEL	N/A
CONDITION OF DISCHARGE CHANNEL	N/A

COMMENTS: The 12-inch cast iron outlet conduit discharges into the spillway discharge channel.

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam (Gatehouse) DATE: 11/26/79

PROJECT FEATURE: Outlet Works - Control Tower NAME: RGL

DISCIPLINE: Civil Engineer NAME: DLS

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	
A. CONCRETE AND STRUCTURAL:	
GENERAL CONDITION	Good
CONDITION OF JOINTS	None observed - chamber filled
SPALLING	None observed
VISIBLE REINFORCING	None observed
RUSTING OR STAINING OF CONCRETE	None observed
ANY SEEPAGE OR EFFLORESCENCE	None observed
JOINT ALIGNMENT	No joints observed
UNUSUAL SEEPAGE OR LEAKS IN GATE CHAMBER	None observed, as chamber is normally filled
CRACKS	None observed
RUSTING OR CORROSION OF STEEL	None
B. MECHANICAL AND ELECTRICAL:	
AIR VENTS	Good
FLOAT WELLS	N/A
CRANE HOIST	Good condition
ELEVATOR	N/A
HYDRAULIC SYSTEM	N/A
SERVICE GATES	Not observed
EMERGENCY GATES	Not observed
LIGHTNING PROTECTION SYSTEM	N/A
EMERGENCY POWER SYSTEM	N/A
WIRING AND LIGHTING SYSTEM IN GATE CHAMBER	N/A

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir DATE: 11/26/79

PROJECT FEATURE: Spillway Weir - Discharge Channel Approach and NAME: RGL, DLS

DISCIPLINE: Geotechnical Engineer - Civil Engineer NAME: GC

AREA EVALUATED		CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS		
A.	APPROACH CHANNEL:	No approach channel
	GENERAL CONDITION:	
	LOOSE ROCK OVERHANGING CHANNEL	
	TREES OVERHANGING CHANNEL	
	FLOOR OF APPROACH CHANNEL	
B.	WEIR AND TRAINING WALLS:	
	GENERAL CONDITION OF CONCRETE	Good
	RUST OR STAINING	Staining of concrete at bottom of stilling basin & wall exp. jts.
	SPALLING	None observed
	ANY VISIBLE REINFORCING	No
	ANY SEEPAGE OR EFFLORESCENCE	Evidence of seepage at wall exp. jts. Seepage from last exp. jt. in floor slab. Effl. near outlets
	DRAIN HOLES	None observed
C.	DISCHARGE CHANNEL:	Downstream of stilling basin
	GENERAL CONDITION	Good, natural streambed
	LOOSE ROCK OVERHANGING CHANNEL	None observed
	TREES OVERHANGING CHANNEL	None of significance
	FLOOR OF CHANNEL	Gravel, boulders
	OTHER OBSTRUCTIONS	Some bushes growing on channel bottom

COMMENTS:

The left training wall is misaligned at the joint downstream of the bridge. This has been monitored by the Water Company for the past several years with no change noted.

PERIODIC INSPECTION CHECK LIST

PROJECT: Mulberry Reservoir Dam DATE: 11/26/79

PROJECT FEATURE: Service Bridges NAME: RGL

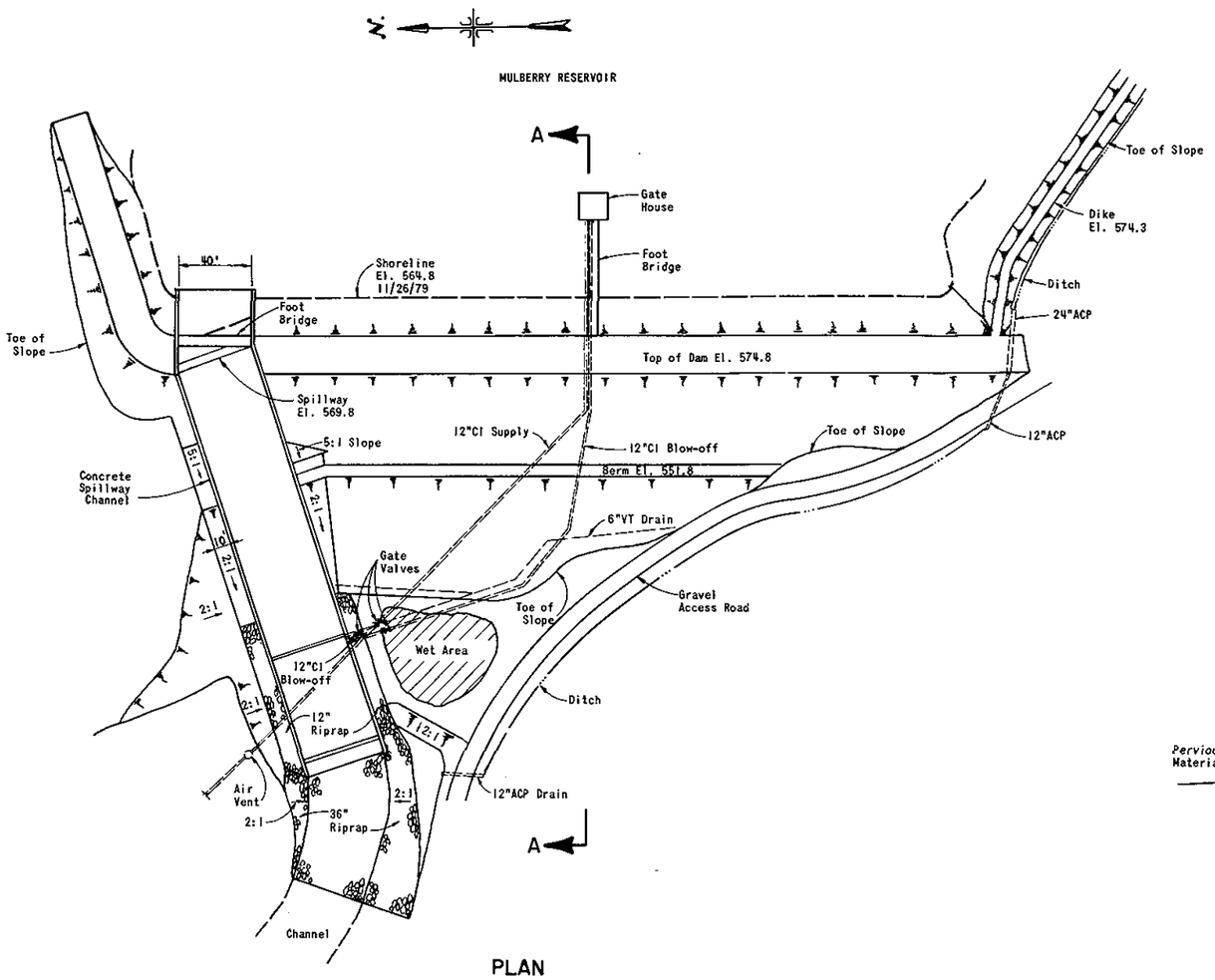
DISCIPLINE: Civil Engineer NAME: DLS

AREA EVALUATED	CONDITIONS	
OUTLET WORKS - SERVICE BRIDGE	Over Spillway	To Gate House
A. SUPER STRUCTURE:		
BEARINGS		
ANCHOR BOLTS	Good	Good
BRIDGE SEAT	Good	Some minor spalling
LONGITUDINAL MEMBERS	Good	Good
UNDER SIDE OF DECK	Good	Good
SECONDARY BRACING	Good	Good
DECK	Good	Good
DRAINAGE SYSTEM	None	None
RAILINGS	Good	Good
EXPANSION JOINTS	Good	Good
PAINT	Good	Good
B. ABUTMENT AND PIERS:		
GENERAL CONDITION OF CONCRETE	Good	Good
ALIGNMENT OF ABUTMENT	Good	Good
APPROACH TO BRIDGE	Good	Cracks in concrete slab
CONDITION OF SEAT AND BACKWALL	Good	Transv. crack in back wall. Some minor spalling.

APPENDIX B

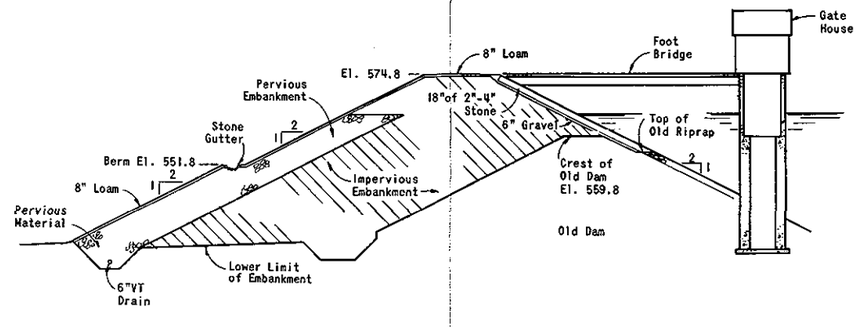
ENGINEERING DATA

FIGURE 2



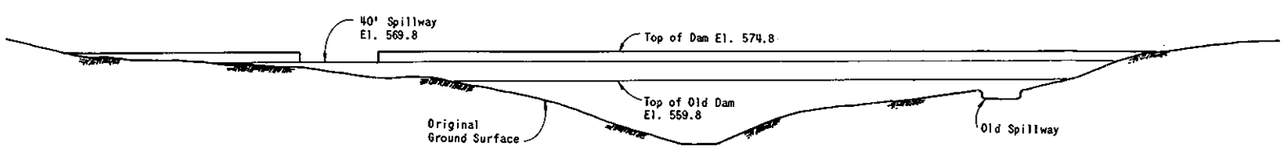
PLAN

Scale 1"=80'



SECTION A-A

Scale 1"=40'



PROFILE

Scale 1"=80'

Notes: Plan and Section partially taken from Connecticut Water Co. Naugatuck Division Dwg. No. MA.75B "Plan and Sections of Dam", by Metcalf & Eddy. Nov. 1964.

Elevations shown are based on USGS Datum.

ROALD HAESTAD, INC. *CONSULTING ENGINEERS* WATERBURY, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND *CORPS OF ENGINEERS* WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

MULBERRY RESERVOIR DAM

DRAWN	CHECKED	APPROVED	SCALES AS NOTED	
JRS	DLS		DATE DEC. 1979	PAGE B-1

LIST OF REFERENCES

References 1 through 4 are located at Connecticut Water Company, Inc., 93 West Main Street, Clinton, Connecticut. References 5 through 7 are located at the Department of Environmental Protection, Office of the Superintendent of Dams, State Office Building, Hartford, Connecticut, 06115.

1. Plans and Specifications, "Mulberry Dam, Naugatuck, Connecticut", Metcalf & Eddy, Boston, Massachusetts, November, 1964.

2. Hydrologic and Hydraulic Spillway Design Computations, Metcalf & Eddy, 1964.

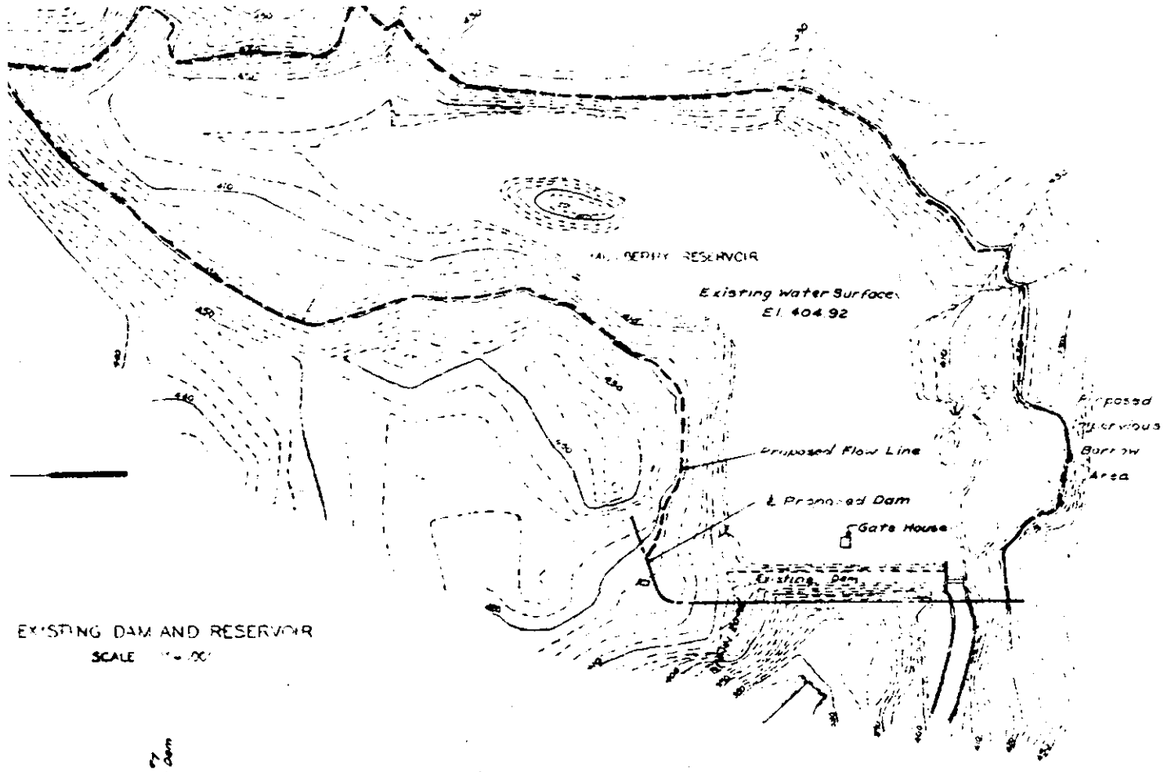
3. Operations and Maintenance Manual, Mulberry Reservoir, Connecticut Water Company, Naugatuck Division, December 1979.

4. Memo "Repair of Expansion Joints - Mulberry Reservoir Spillway", Connecticut Water Company, July 1979.

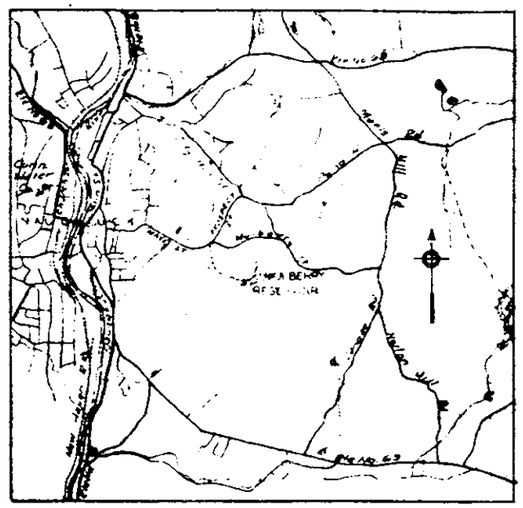
5. Application for Construction Permit for Dam, Connecticut Water Company, November 1964.

6. Inspection Report "Mulberry Dam", Roger C. Brown, Clarence Blair Associates, June 1966.

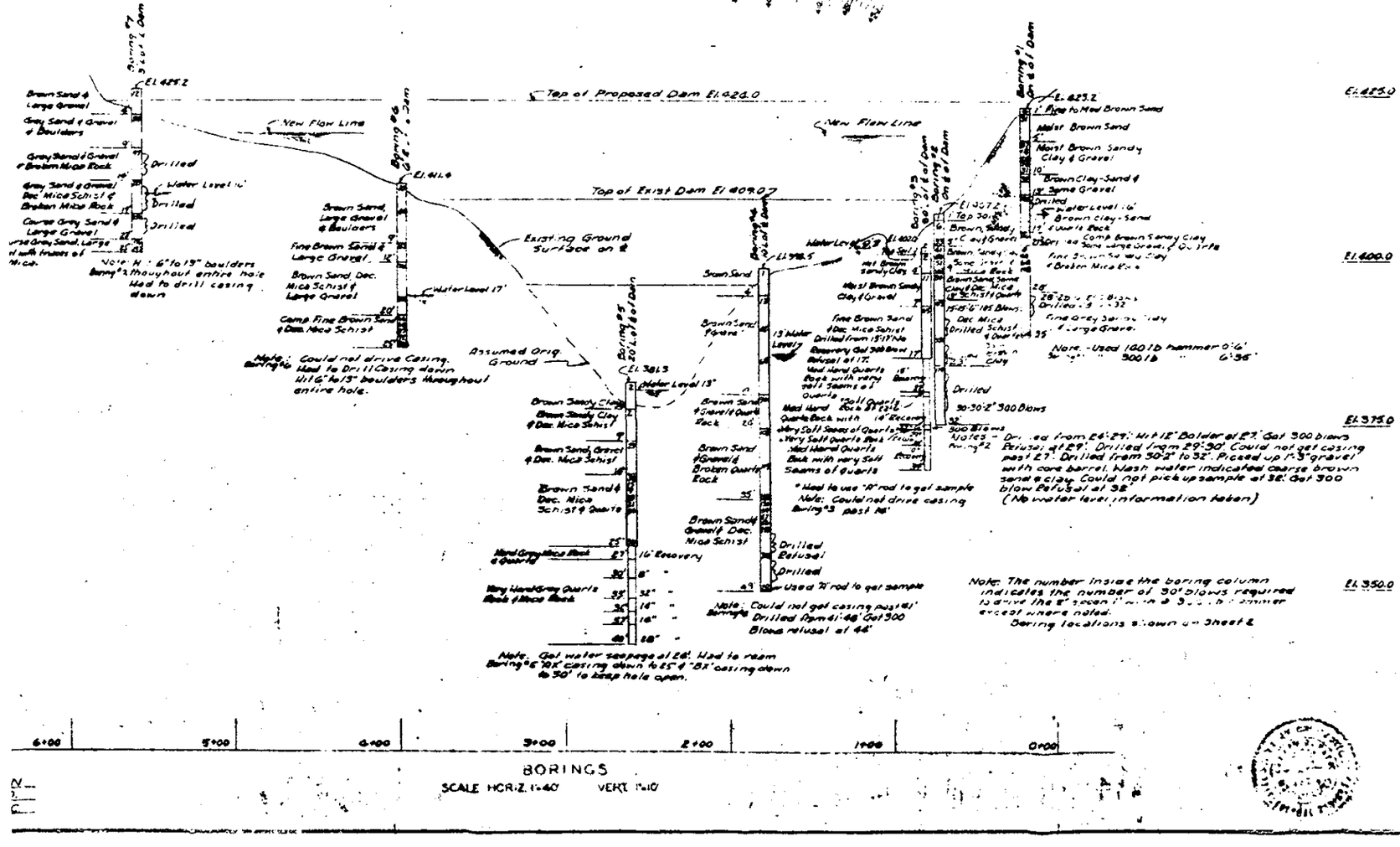
7. Certificate of Approval, State of Connecticut, Water Resources Commission, July 1966.



EXISTING DAM AND RESERVOIR
SCALE 1" = 100'



LOCATION PLAN
SCALE 1" = 1/2 MILE



BORINGS
SCALE HORIZ. 1"=40' VERT. 1"=10'

NOTE: ELEVATIONS SHOWN ARE BASED ON BOROUGH OF NAUGATUCK DATUM
NAUGATUCK DATUM +150.79' = USGS DATUM

DRAWING NO. NA-75A-1

HALF SIZE

APPROVED
FOR METCALF & EDDY, ENGINEERS
[signature]
REG. PROF. ENGR. CONN. NO. 4020
11/16/64
DATE

CONNECTICUT WATER COMPANY
NAUGATUCK DIVISION

MULBERRY DAM
NAUGATUCK, CONN.

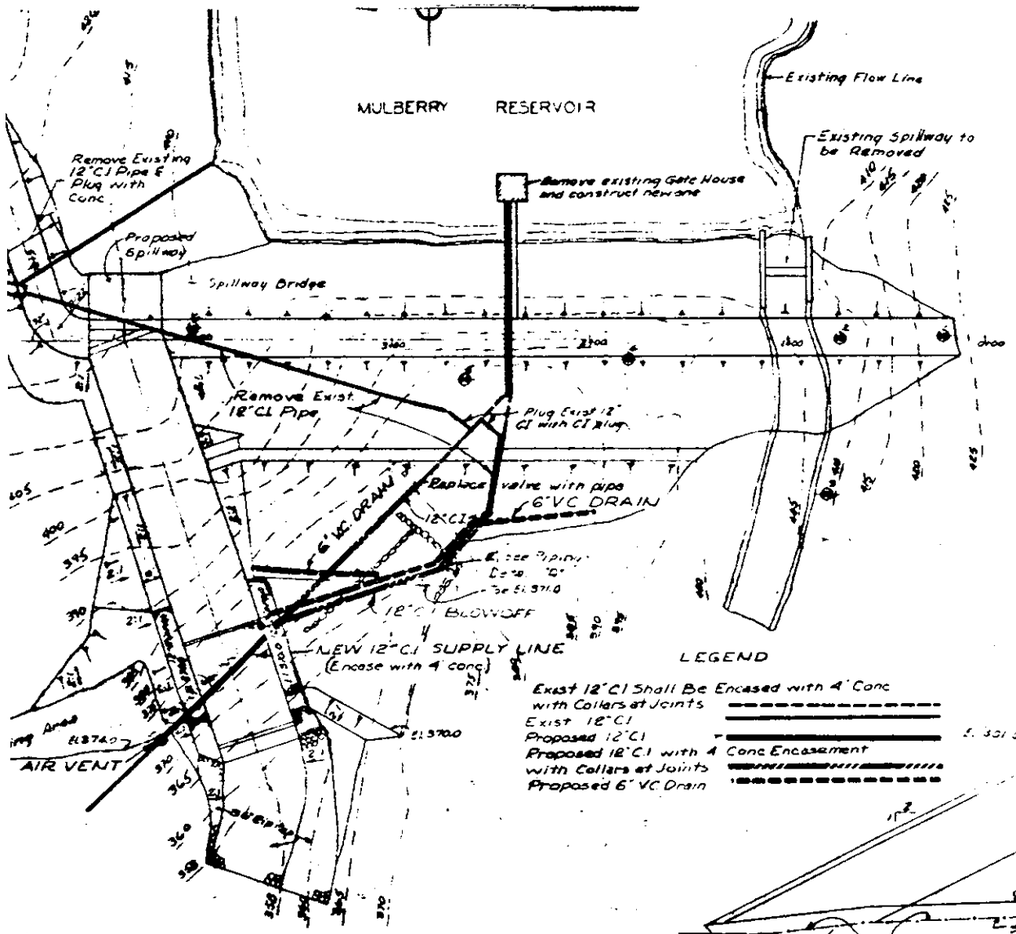
EXISTING RESERVOIR & BORINGS

SCALE AS SHOWN NOV. 1964

METCALF & EDDY
ENGINEERS
BOSTON, MASS.

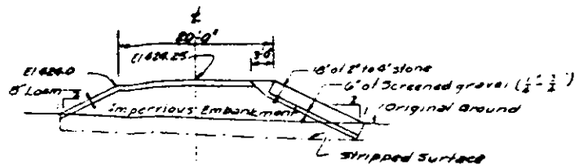
B-3

29629

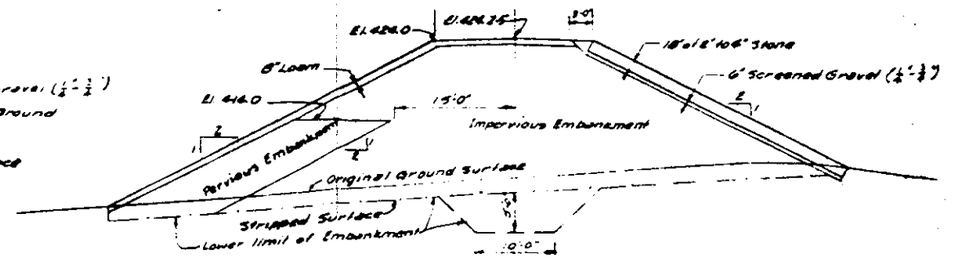


PLAN OF DAM
SCALE 1"=40'

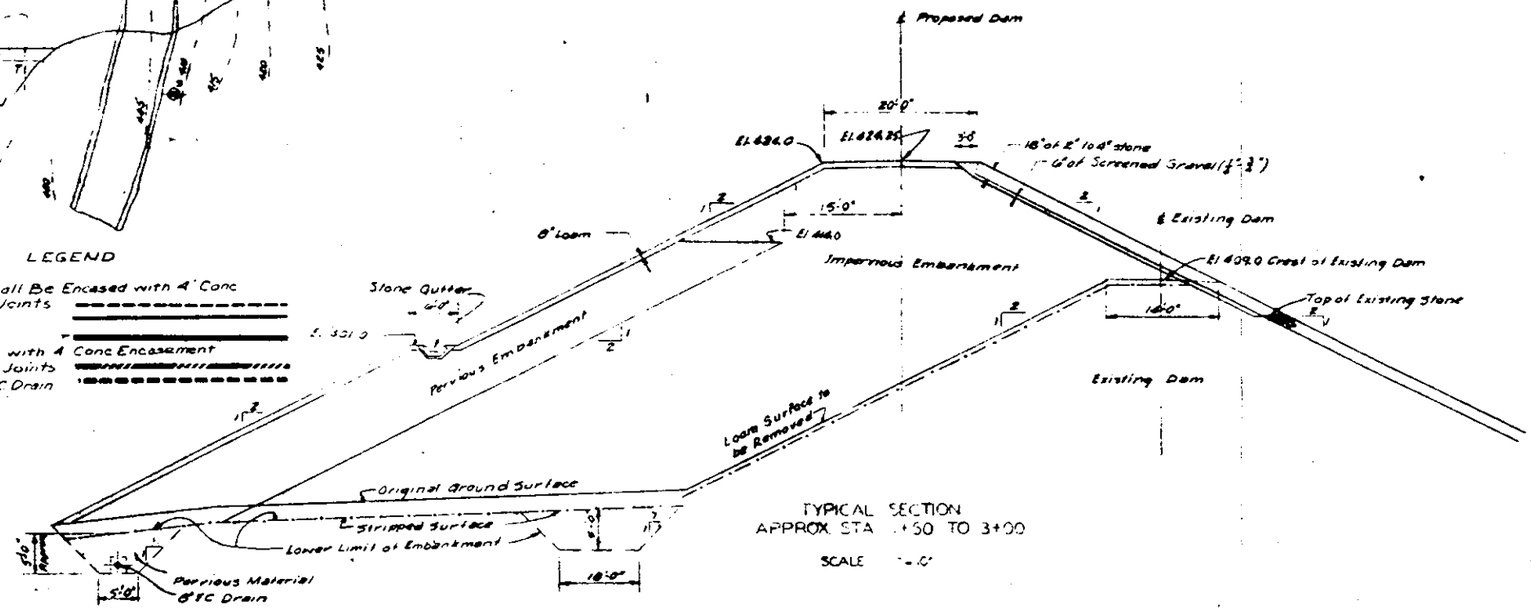
Note:
⊕: Boring Location
All C.I. pipe shown is existing except as noted.
All V.C. shown is new.



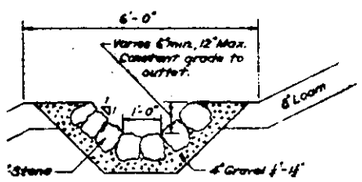
TYPICAL SECTION
ORIGINAL GROUND ABOVE EL 4190
SCALE 1"=10'



TYPICAL SECTION
APPROX. STA 0+20 TO +50
APPROX. STA 3+70 TO 4+15
SCALE 1"=10'

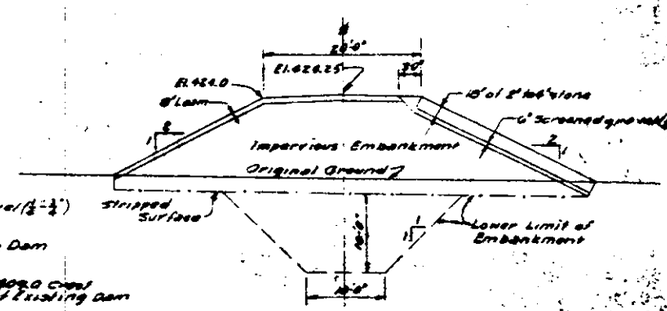


TYPICAL SECTION
APPROX. STA .+50 TO 3+00
SCALE 1"=10'



DETAIL OF STONE GUTTER
SCALE 1"=2'-0"

TYPICAL SECTION
APPROX. STA 3+00 TO 3+70
SCALE 1"=10'



TYPICAL SECTION
APPROX. STA 4+55 TO 5+10
SCALE 1"=10'

DRAWING NO: NA.75 B

HALF SIZE

NOTE: ELEVATIONS SHOWN ARE BASED ON BOROUGH OF NAUGATUCK DATUM
NAUGATUCK DATUM +150.79'= USGS DATUM

APPROVED
FOR METCALF & EDDY, ENGINEERS
REGD. PROF. ENGR. CONN. NO. 4030 DATE 11/14/64

CONNECTICUT WATER COMPANY
NAUGATUCK DIVISION

MULBERRY DAM
NAUGATUCK, CONN.

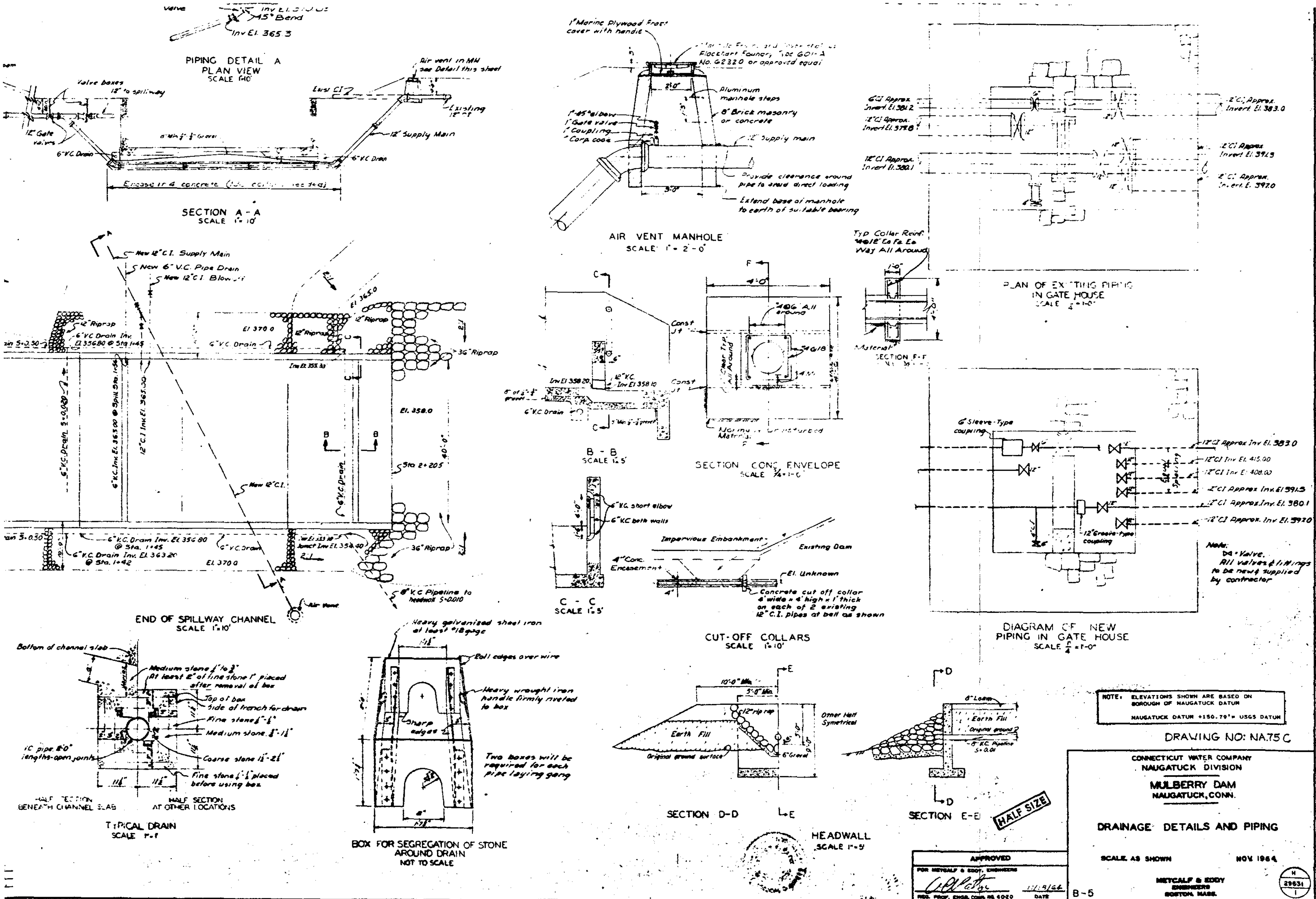
PLAN & SECTIONS OF DAM

SCALE AS SHOWN NOV. 1964

METCALF & EDDY
ENGINEERS
BOSTON, MASS.

29630

B-4



DRAWING NO: NA75C

CONNECTICUT WATER COMPANY
NAUGATUCK DIVISION

MULBERRY DAM
NAUGATUCK, CONN.

DRAINAGE DETAILS AND PIPING

SCALE AS SHOWN — NOV. 1964

APPROVED
FOR METCALF & EDDY, ENGINEERS
REG. PROF. ENGR. CONN. NO. 6020 — DATE 11/9/64

B-5

METCALF & EDDY
ENGINEERS
BOSTON, MASS.

29631

PLAN OF SPILLWAY

SECTION A-A

B - B

C - C

D - D

E - E

F - F

TYP. DETAIL A
SCALE: 1" = 1'-0"

TYP. DETAIL B
SCALE: 1" = 1'-0"
Typ. for Wall Footings as shown in Sect A-A

TYP. DETAIL C
SCALE: 1" = 1'-0"
Typ. for Wall Footings as shown in Sect A-A

TYP. DET. E
NO SCALE

TYP. JT DET. D
SCALE: 3" = 1'-0"

NOTE: ELEVATIONS SHOWN ARE BASED ON BOROUGH OF NAUGATUCK DATUM
NAUGATUCK DATUM +150.79' = USGS DATUM

Note:
For Sections 1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 7-7 & 8-8, 9-9, 10-10, 11-11 & 12-12 See Sh. 5
For Typ. Details & General Notes see Structural Standards Sh. 10
For Sections 13-13, & 14-14 See Sh. 6

HALF SIZE

DRAWING NO: NA.75 D

APPROVED
FOR METCALF & EDDY, ENGINEERS
REG. PROF. ENGR. CONN. NO. 4020
DATE 11/15/64

CONNECTICUT WATER COMPANY
NAUGATUCK DIVISION

MULBERRY DAM
NAUGATUCK, CONN.

STRUCTURAL

SPILLWAY - PLAN & SECTIONS - I

SCALE 1" = 10' EXCEPT AS NOTED NOV. 1964

METCALF & EDDY
ENGINEERS
BOSTON, MASS.

B-6

- S A M P L E -

The Connecticut State Water Commission
State Board of Supervision of Dams
113 Thayer Building
Norwich, Connecticut

Attention: Mr. Benjamin M. Palmer

Gentlemen:

Forwarded under separate cover are one set of contract drawings and one set of contract documents for the raising of Mulberry Dam and appurtenant work in Naugatuck, Connecticut. The project will provide additional capacity for the high-service system of the Connecticut Water Company, Naugatuck Division.

The principal design data are as follows:

Drainage area, sq.mi. -	0.23
Area of water surface, acres -	10.9
Volume of water below spillway crest, mil.gal. -	48.5
Elevation of top of dam -	424.0
Elevation of spillway crest -	419.0
Freeboard above spillway crest, ft. -	5.0
Length of spillway -	40.0
Water surface, elevation at design flood, ft. -	421.9
Freeboard at design flood, ft. -	2.1
Design flood at spillway, cfs. -	575
Design flood inflow to reservoir, cfs. -	575

The maximum rate of inflow to the reservoir was computed by the following formula (Boston Society of Civil Engineers formula):

$$I = C_f R A$$

Where I = maximum rate of inflow, in cubic feet per second

C_f = coefficient based on stream flow records and the nature of watershed

R = 6 in. of runoff

A = area of watershed

The spillway capacity was computed from the following formula:

$$Q = C L H^{3/2}$$

Where Q = spillway discharge, in cubic feet per second

C = coefficient taken as 3.55

L = length of spillway, in feet

H = head on weir, in feet

It will be appreciated if you will review the project so that any revisions can be made by our engineers. If any additional information concerning the design of the dam is required, please contact Metcalf & Eddy, Engineers, 1300 Statler Building, Boston 16, Massachusetts, to the attention of Mr. Charles E. Cannon.

Very truly yours,

OPERATIONS AND MAINTENANCE MANUAL

Mulberry Reservoir

Mulberry Reservoir is a public water supply distribution reservoir for the Naugatuck Division of the Connecticut Water Company. The dam is located at the west end of the reservoir in the town of Naugatuck. The entrance to the dam is from Gabriel Drive which is off of Mulberry Road. See attached map. The dam at Mulberry Reservoir was raised 25 feet and rebuilt in 1965. The surface area at spilling was 9.2 acres. It is now 11 acres. The watershed of Mulberry Reservoir is 148 acres (.23 square miles). In 1897 the Hopkins watershed, located to the northeast, was diverted to the Mulberry watershed. This increased the total watershed area to 409 acres (.64 square miles). At the spillway crest 570 (USGS 1964) the storage capacity of the reservoir is 50 million gallons. The estimated safe yield of Mulberry is .35 MGD. This distribution reservoir provides suction for the Mulberry Booster Pump which supplies a portion (approximately 43 percent) of the high service area in Naugatuck.

The dam at Mulberry Reservoir is a straight earth filled embankment. The 575 foot dam has a maximum height of 41 feet. The grassed crest averages 20.0 feet in width. The upstream face is gradually sloping with rip rap protection from the base to the crest. The spillway, which was rebuilt in 1965, is a 40 foot reinforced concrete overflow weir with a 60" freeboard.

The control of reservoir water to the booster pump is accomplished by five 12" intake gate valves. The elevations of these intakes are: 566.0 feet, 559.0 feet, 548.0 feet, 542.3 feet, and 534.0 feet. Water from the reservoir flows through one of these intakes, into the gatehouse, through the screens and exits via the 12" outlet piping. Depending on lake level, the corresponding intake valve is opened.

Four other gate valves are located within the gatehouse. One 12" gate valve is labeled, in red, as mud gate. This piping has a 4" branch gate and is located at elevation 531.1. These gates are used for draining the reservoir and the gatehouse. A 6" gate valve is used if only the gatehouse is to be drained. The final gate is the 12" outlet gate which is always in the opened position. The north wall of the gatehouse has a diagram of the valving, a copy of which is included in this manual.

The average summer drawdown is about six feet. The lowest lake level was recorded at 12.4 feet on November 15, 1973. Flood flows have been read at high as .5 feet. Spillway capacity under normal conditions is 575 cfs spilling 2.9 feet based on 6" runoff.

The entrance to Mulberry Reservoir is fenced and the access gate off Gabriel Drive is locked at all times. The reservoir is patrolled daily at various hours. The patrol of the area includes:

a.) A check of the spillway for debris and obstacles.

b.) A check of the stream and pipe from the Hopkins diversion.

c.) Any unusual activities, e.g. motorcycles, horseback riders, dead animals, animal burrows, etc.

Trespassing is not allowed on Water Company lands. All problems and violations are reported to the Division Manager as soon as possible. In addition to the patrolman, the pump station attendant inspects and maintains the aeration equipment at the reservoir.

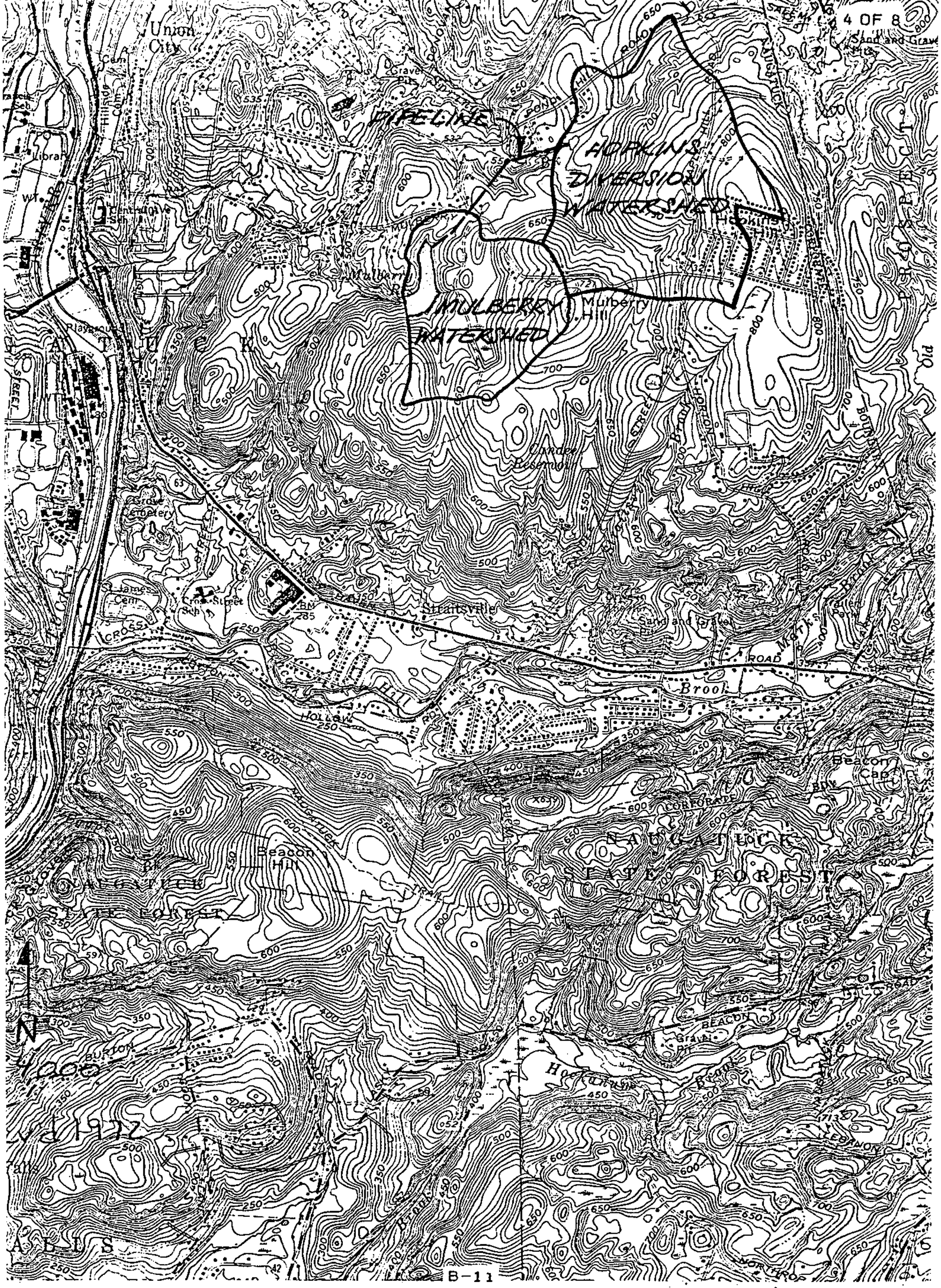
Inspections of the embankments and foundations are at regular intervals using form CWC E-19. A copy of a typical inspection report is attached. Tree growth along the artificial fill area is closely monitored and is not allowed to encroach upon the fill area. Seasonal maintenance is done as required. Reservoir screens and the diversion intake are cleaned twice a year. Water Company lands near the reservoir are managed by Connwood of Rockfall, CT.

Copies of this manual are distributed to the Division Manager and Engineering Dept.

VFS/be

OPERATING AND EMERGENCY PERSONNEL

Patrolman - William Hill		729-3887
Division Manager - William Dunn	office	729-8241
	home	754-7941
Office Manager - Edward Rahn	office	729-8241
	home	272-9737
Standby (answering service) after hours		729-8241
Chief Engineer - William Guillaume		669-5463
Construction Engineer - Kenneth Kells		767-0535
Quality Engineer - Jim McQueen		388-3914
Naugatuck Police		729-5221
State Police (Troop 1), Bethany		756-8069
DEP - Oil Spill		566-3338


PIPELINE
HOPKINS DIVERSION WATERSHED
MULBERRY WATERSHED
Union City
Mulberry Hill
Hopkins Hill
Straitsville
Beacon Hill
Beacon Cap
NAUGATUCK STATE FOREST
Grove Cemetery
Brook
Beacon
Hockanum Brook
Sand and Gravel Pits
Gravel Pits
4000
1972

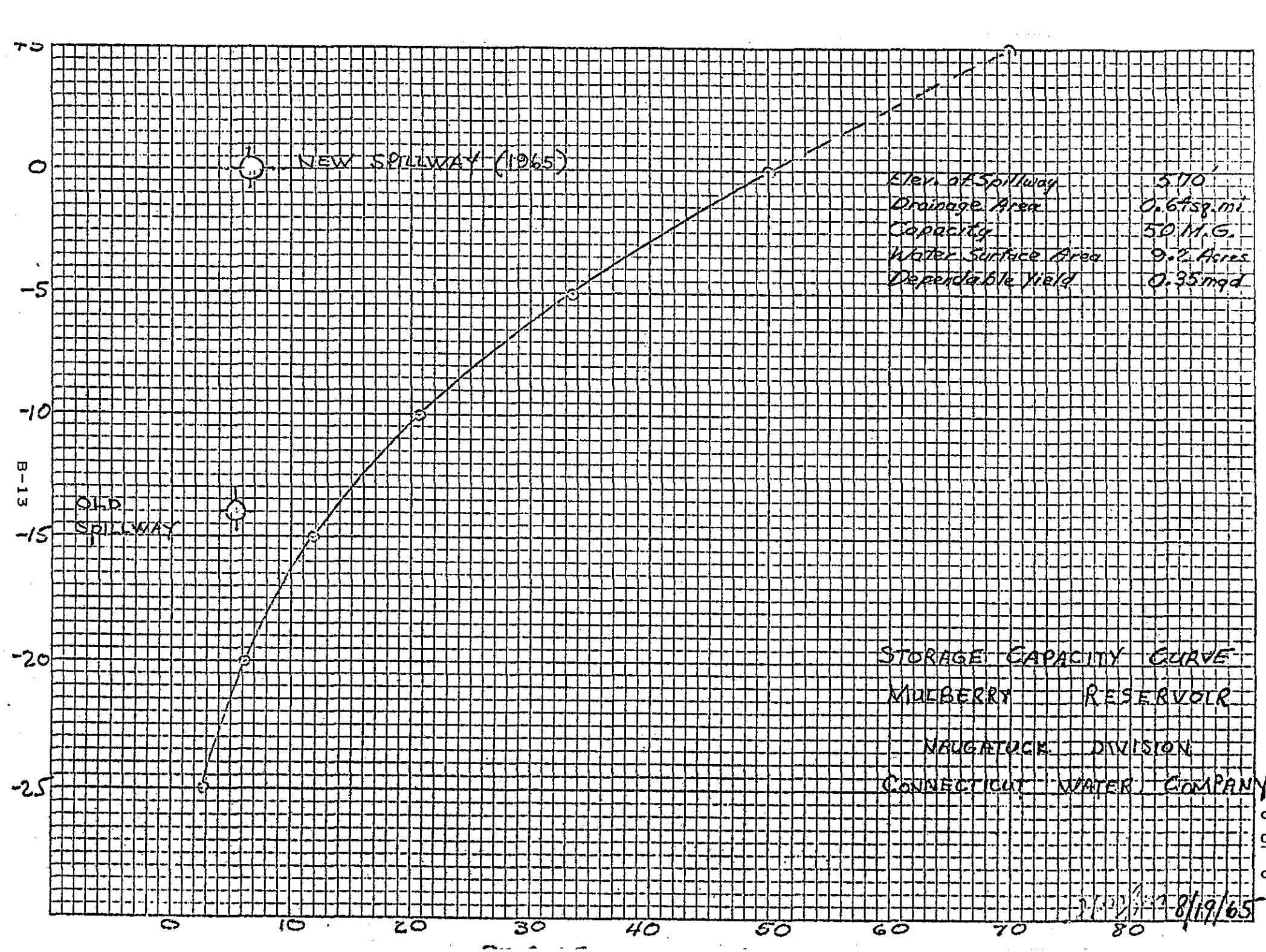
Mulberry Reservoir

	M.G.
0' 0"	50.0
2	49.4
4	48.8
6	48.2
8	47.6
10	47.0
1' 0"	46.4
2	45.8
4	45.2
6	44.6
8	44
10	43.5
2' 0"	43.0
2	42.4
4	41.8
6	41.2
8	40.6
10	40.0
3' 0"	39.5
2	39.0
4	38.5
6	38.0
8	37.5
10	37.0
4' 0"	36.5
2	36.0
4	35.5
6	35.0
8	34.5
10	34.0
5' 0"	33.5
2	33.0
4	32.5
6	32.0
8	31.5
10	31.0
6' 0"	30.5

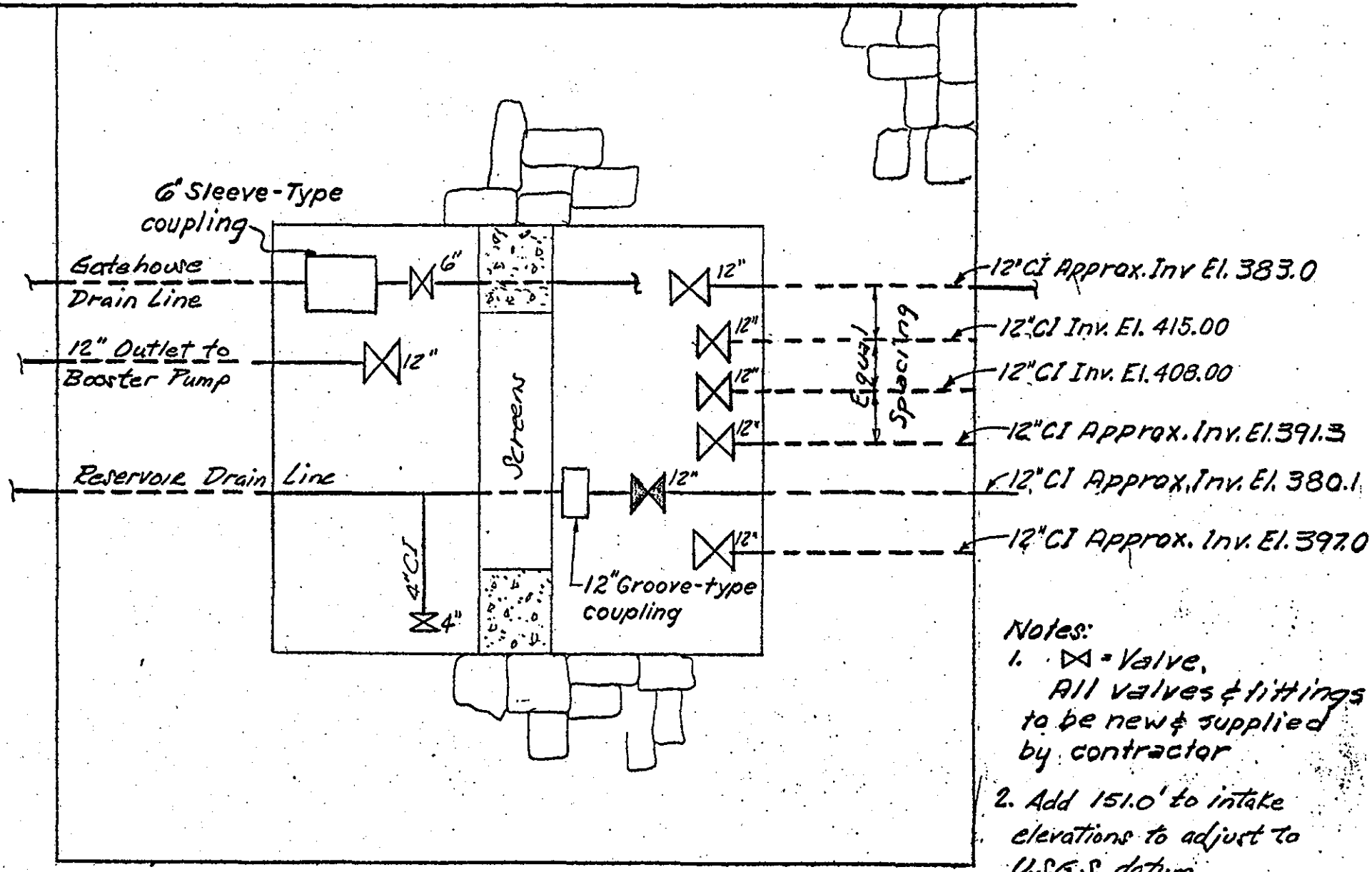
	M.G
2	30.0
4	29.6
6	29.1
8	28.7
10	28.2
7' 0"	27.8
2	27.3
4	26.9
6	26.5
8	26.1
10	25.7
8' 0"	25.3
2	24.8
4	24.4
6	24.0
8	23.6
10	23.2
9' 0"	22.8
2	22.4
4	22.1
6	21.7
8	21.4
10	21.0
10' 0"	20.7
2	20.3
4	20.0
6	19.7
8	19.3
10	19.0
11' 0"	18.7
2	18.3
4	18.0
6	17.7
8	17.3
10	17.0
12' 0"	16.8

NOTE:

Tabulated figur
are gross volume
in storage. When
figuring availabl
supply subtract
6 M.G.


NEW SPILLWAY (1965)
OLD SPILLWAY
Elev. of Spillway 510'
Drainage Area 0.64 sq. mi.
Capacity 50 M.G.
Water Surface Area 9.2 Acres
Dependable Yield 0.35 mgd
STORAGE CAPACITY CURVE
MULBERRY RESERVOIR
NAUGATUCK DIVISION
CONNECTICUT WATER COMPANY
8/19/65
B-13
+5
0
-5
-10
-15
-20
-25
0
10
20
30
40
50
60
70
80

MULBERRY RESERVOIR GATEHOUSE



Notes:
1. ⋈ = Valve. All valves & fittings to be new & supplied by contractor
2. Add 151.0' to intake elevations to adjust to U.S.G.S. datum.

DIAGRAM OF NEW PIPING IN GATE HOUSE
SCALE $\frac{1}{4}$" = 1'-0"

VISUAL INSPECTION CHECKLIST FOR DAMS

The Connecticut Water Company

Dam Name: Mulberry Inspection Date: 10-18-79

Present at Inspection: Bill Hill

Reservoir Level: 6-0

General condition of slopes or dam faces: Good

Any evidence of erosion on upstream face? None

On downstream face? None

Any unwanted tree growth? N/O

Any animal burrows in slopes? N/O

Any notable earth movements? N/O

Any spongy spots or noticeable seepage? N/O

Spillway condition: Good

Spillway Obstructions: None

Tail Race Conditions: Good

Downstream obstructions or undermining of spillway or splash pad: N/O

Comments or recommendations:

Prepared by: Bill Hill date 10-18-79

Reviewed by: F. E. Hill date 10/23/79

Distribution: KWK

Conn-E-19

T. KRESTAD INC.

INTER OFFICE MEMO — THE CONNECTICUT WATER COMPANY

Re: Repair of Expansion Joints - Mulberry Reservoir Spillway

July 24, 1979

R. J. Ulkus

BLOOM	☐	MacKENZIE	☐
BURRILL	☐	RAHN	☐
DILLON	☐	SHAW	☐
DUNN	☒c	STEWART	☐
GUILLAUME	☐	SWANSON	☐
KELLS	☒k	SYMMES	☐
LAFLAMME	☐	TARNOWICZ	☐
	☐		☐

On July 18 I inspected the spillway expansion joints repaired August, 1976. It was noted that approximately 80 percent of the north-south and 10 percent of the east-west joint filler has failed.

The failure appears to be caused by water getting below the joint material, due to a failure in the Sika-Flex caulking used, and going through a number of freeze-thaw cycles thus breaking the bond between the filler material and the concrete slab causing the filler material to lift.

To repair the failures, I would recommend the following:

1.) Caulk all cracks and exposed edges in the east-west joints using a polysulfide 1 component sealant. Continue to inspect monthly, repair all new cracks or failures in the polysulfide sealant as soon as noticed.

2.) Remove all joint filler material from the north ~~side~~ South (shorter) joints. Wire brush to clean all exposed concrete.

3.) Coat all exposed concrete in joint with a resin emulsion bonding agent. Fill joint with rich cement grout per attached sketch.

4.) After grout has hardened and been given a chance to shrink, install polysulfide joint sealant with cork backup. Caulk seams between grout and concrete slabs with 1 component polysulfide sealant.

5.) Continue to inspect, repair all cracks as soon as possible with polysulfide sealant.

ALCULATION - EXPANSION possible PER JOINT

AB SIZE - 25' X 29'

ONE MAX TEMP Δ 100° F

C. EXPANSION REINFORCED CONCRETE .000006 "/L.F./ # / °F

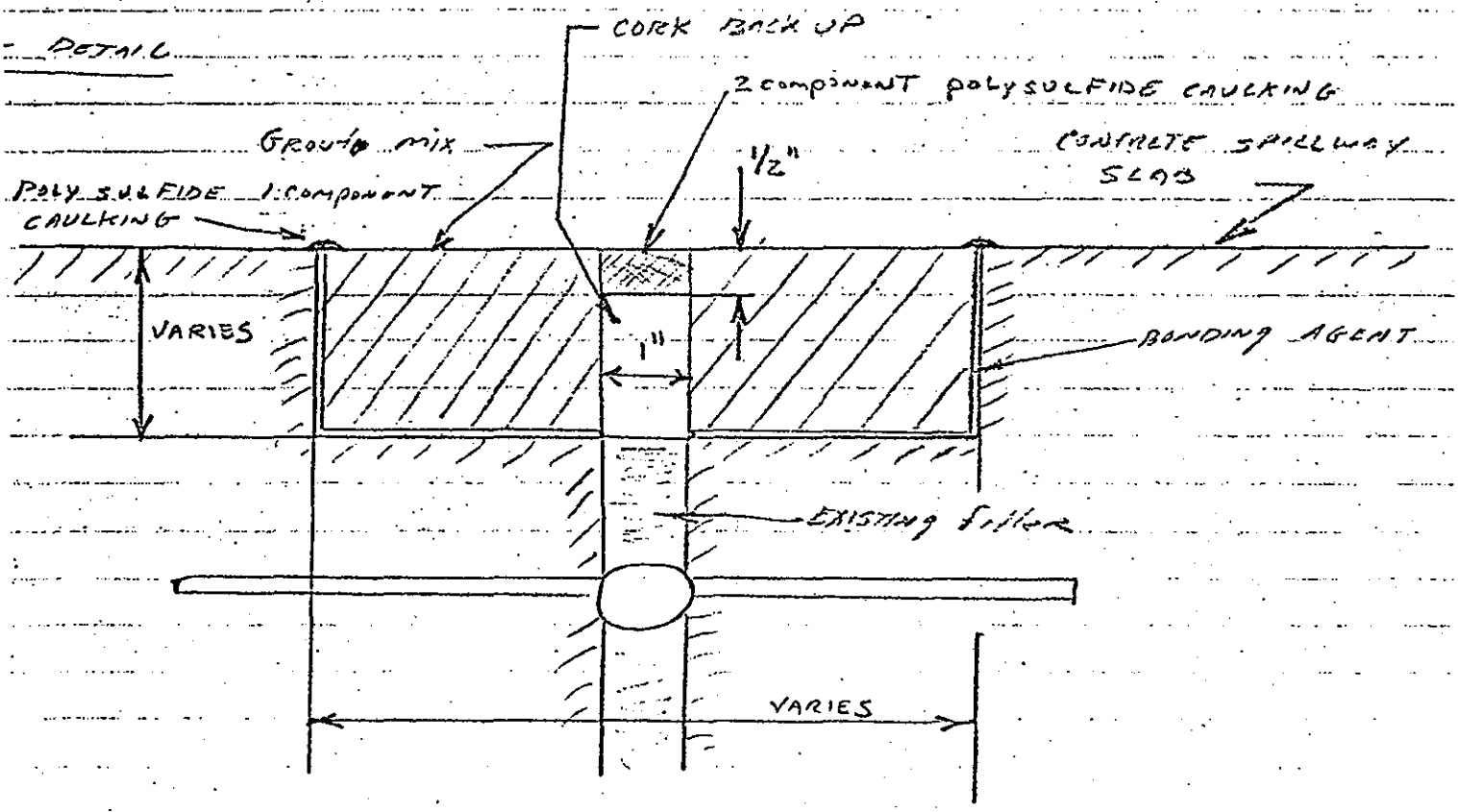
XPANSION PER JOINT

.000006 X 25' X 100°F X 12 = .18" ≈ 3/16" SAY 1/9" PER JOINT

fide CAULKING has MOVEMENT CAPABILITY of 25%± of ITS WIDTH). THEREFORE SHOULD BE 1" WIDE to ALLOW EXPANSION AND STILL BE WITH IN MOVEMENT of CAULKING

ack up MATERIAL will compress up to 50%± of ITS WIDTH.

DETAIL



AND CONTROL of CONCRETE MIXTURES - PORTLAND CEMENT ASSOCIATION ELEVENTH EDITION

FORM D-4

STATE OF CONNECTICUT
WATER RESOURCES COMMISSION
Room 317, State Office Building
Hartford, Connecticut

APPLICATION FOR CONSTRUCTION PERMIT FOR DAM

Owner Connecticut Water Company — Date November 3, 1964
Naugatuck Division
P. O. Address 250 Meadow Street
Naugatuck, Connecticut — Tel. No. PArk 9-8241

Location of Structure:

Town Naugatuck — Shown on USGS Quadrangle Naugatuck 1:24,000

Name of Stream Unknown
Existing Mulberry Res.

at 2.85 inches south of Lat. 41°-30'
and 4.50 inches ~~east~~ west of Long. 73°-00'

Directions for reaching site from nearest village or route intersection:
(see sketch on reverse side)

At intersection of May, Prospect and Mulberry Streets proceed southward along unimproved road 2,000 ft. to existing Mulberry Dam.

This is an application for: (New Construction) (Alteration) (Repair) (Removal) X
(check one or more of above)

This pond is to be used for: Water Supply for Naugatuck

Dimensions of Pond: width 500 ft. length 1,450 ft. area 11.3 acres

Maximum depth of water immediately above dam: 40 ft.

Total length of dam: 575 ft.

Length of spillway: 40 ft.

Height of abutments above spillway: 5 ft.

Type of spillway construction: Concrete Ogee

Type of dike construction: Rolled earth

Spillway section will be set on: (Bedrock) (Gravel) (Clay) (Till) X
(check one of above)

Remarks: Storage capacity of Mulberry Reservoir to be increased by raising height of existing dam.

Signed: The Conn. Water Co.
By Wm Neal MacKenzie
(owner) Exec. Vice Pres.

Name of Engineer, if any Metcalf & Eddy
1200 Statler Building
Boston, Massachusetts

Note: Show details of construction on reverse side.

CLARENCE BLAIR ASSOCIATES

Civil and Sanitary Engineers

93 WHITNEY AVENUE

P. O. BOX 236

NEW HAVEN, CONNECTICUT 06502

TEL. 777-7379

ER C. BROWN
ES C. BEACH
IK RAGAINI

ENCE M. BLAIR
(1904-1944)

CHARLES E. AUGUR, JR.
JOHN M. BREST
DONALD L. DISBROW
NICHOLAS PIPERAS, JR.

June 23, 1966

State Water Resources Commission
State Office Building
Hartford 15, Connecticut

Attention: Mr. William P. Sander
Engineer - Geologist

Re: MULBERRY DAM
Naugatuck, Connecticut

Gentlemen:

On June 22, 1963, I made a final inspection of the Mulberry Dam of the Naugatuck Division of the Connecticut Water Company. The Dam is completed and I recommend that a Certificate of Approval be issued.

Very truly yours,

Roger C. Brown

Roger C. Brown
Consulting Engineer

RCB:eb

June 22, 1966

t Board
Henry Dam
augatuck.

On June 22 I made a final inspection of the Mulberry Dam of the Naco Water Co.
Was accompanied by Mr Dunn. Div Supt for the Water Co.
The dam was complete and very nicely finished. According to Dunn it was finished last fall and had been up to spillway level.
At the time of my visit it was down 2 to 2.5 feet. Water was being ~~drawn~~ drawn into the system.

~~There was~~

There was a noticeable flow in the brook ~~at~~ below the toe of the dam. That point at which the ~~brook bed is lost~~ original brook bed is first visible is some distance below the toe of the dam. due to spillway channel and paving.
Some of the stream flow may have been coming from the sides of the valley below the dam
The toe drains discharge into the spillway chute (concrete) and were not discharging much water.

Recommended Certificate of Approval

STATE OF CONNECTICUT

WATER RESOURCES COMMISSION

STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

CERTIFICATE OF APPROVAL

July 19, 1966

Connecticut Water Company
Naugatuck Division
250 Meadow Street

TOWN: Naugatuck
RIVER: Naugatuck River
TRIBUTARY: Unnamed
CODE NO.: N 13.5 U 1.4

Gentlemen:

NAME AND LOCATION OF STRUCTURE: Mulberry Reservoir Dam, located on an unnamed tributary to the Naugatuck River.

DESCRIPTION OF STRUCTURE AND WORK PERFORMED: Rolled earth dam, work to include raising the existing dam 14 feet.

CONSTRUCTION PERMIT ISSUED UNDER DATE OF: December 14, 1964

This certifies that the work and construction included in the plans submitted, for the structure described above, has been completed to the satisfaction of this Commission and that this structure is hereby approved in accordance with Section 25-114 of the 1958 Revision of the General Statutes.

The owner is required by law to record this Certificate in the land records of the town or towns in which the structure is located.

WATER RESOURCES COMMISSION

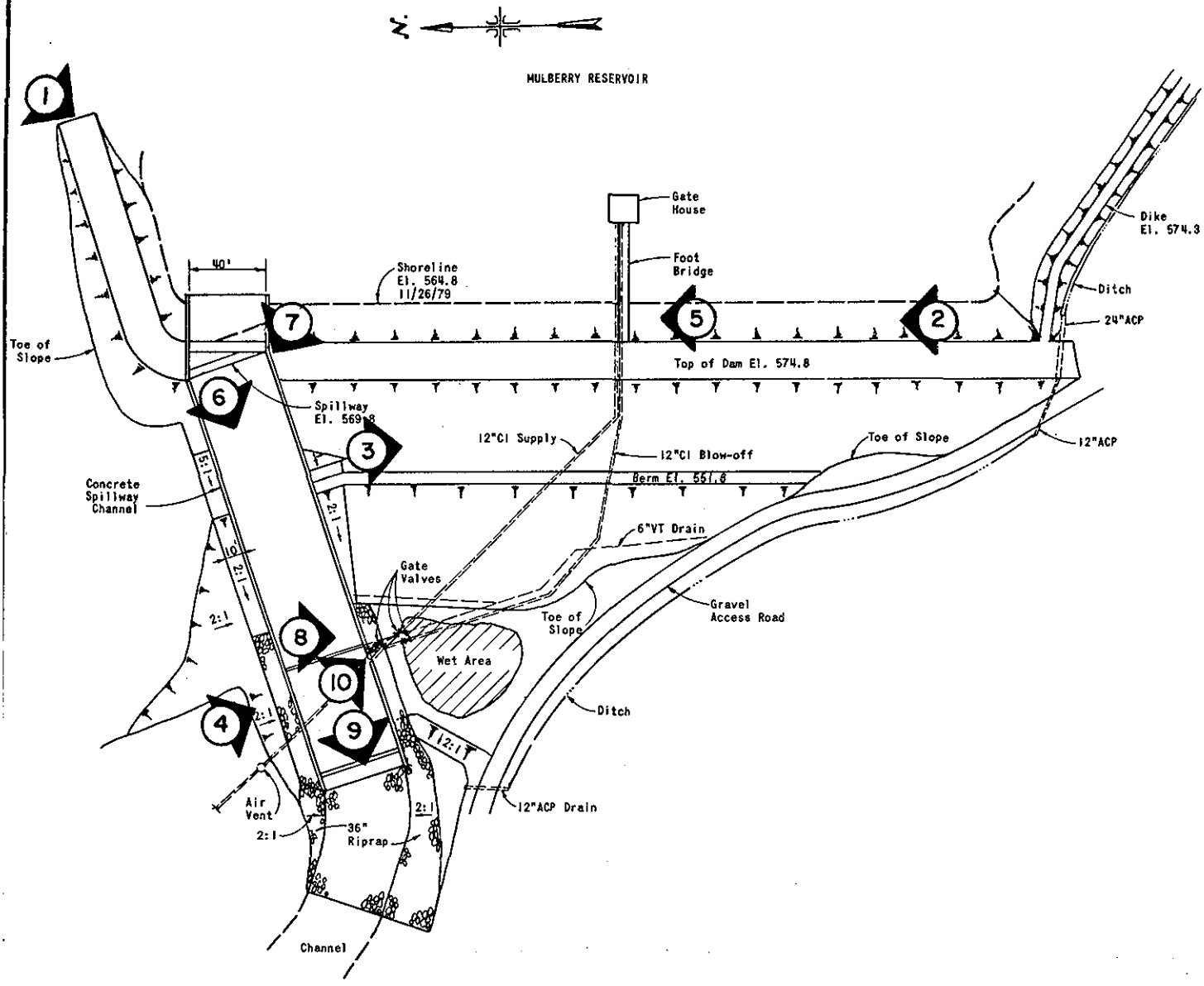
BY: _____
William S. Wise, Director

WSW:js

APPENDIX C

PHOTOGRAPHS

FIGURE 3



DENOTES PHOTO NUMBER AND DIRECTION IN WHICH PHOTO WAS TAKEN

PHOTO LOCATION PLAN

MULBERRY RESERVOIR DAM
NAUGATUCK, CONNECTICUT

SCALE: 1" = 80'

ROALD HAESTAD, INC.

DECEMBER 1979

PHOTO NO. 1

UPSTREAM SLOPE PROTECTION
SPILLWAY AND GATEHOUSE

PHOTO NO. 2

CLOSE-UP OF UPSTREAM EDGE OF CREST

U.S.ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	MULBERRY RESERVOIR DAM TR. TO NAUGATUCK RIVER NAUGATUCK, CONNECTICUT CT 00130 DATE: 26 NOV '79
ROALD HAESTAD, INC. CONSULTING ENGINEERS WATERBURY, CONNECTICUT		

PHOTO NO. 3

AREA OF MINOR EROSION
ON DOWNSTREAM SLOPE

PHOTO NO. 4

WET AREA DOWNSTREAM OF DAM
AND LEFT OF SPILLWAY

U.S.ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	MULBERRY RESERVOIR DAM TR. TO NAUGATUCK RIVER NAUGATUCK, CONNECTICUT CT 00130 DATE: 26 NOV '79
ROALD HAESTAD, INC. CONSULTING ENGINEERS WATERBURY, CONNECTICUT		

PHOTO NO. 5

GATEHOUSE BRIDGE PIER
TRANSVERSE CRACK IN PIER SUPPORTING STEEL BEAM

PHOTO NO. 6

SPILLWAY DISCHARGE CHUTE AND STILLING BASIN

U.S.ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	MULBERRY RESERVOIR DAM TR. TO NAUGATUCK RIVER NAUGATUCK, CONNECTICUT CT 00130 DATE: 26 NOV '79
ROALD HAESTAD, INC. CONSULTING ENGINEERS WATERBURY, CONNECTICUT		

PHOTO NO. 7

LATERAL DISPLACEMENT ACROSS CONSTRUCTION JOINT IN LEFT TRAINING WALL OF SPILLWAY AT CREST OF DAM

PHOTO NO. 8

SEEP THROUGH CONSTRUCTION JOINT IN LEFT WALL OF SPILLWAY AT UPSTREAM END OF STILLING BASIN

U.S.ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	MULBERRY RESERVOIR DAM TR. TO NAUGATUCK RIVER NAUGATUCK, CONNECTICUT CT 00130 DATE: 26 NOV '79
ROALD HAESTAD, INC. CONSULTING ENGINEERS WATERBURY, CONNECTICUT		

PHOTO NO. 9

WATER SEEPING THROUGH CONSTRUCTION JOINT
IN STILLING BASIN FLOOR SLAB

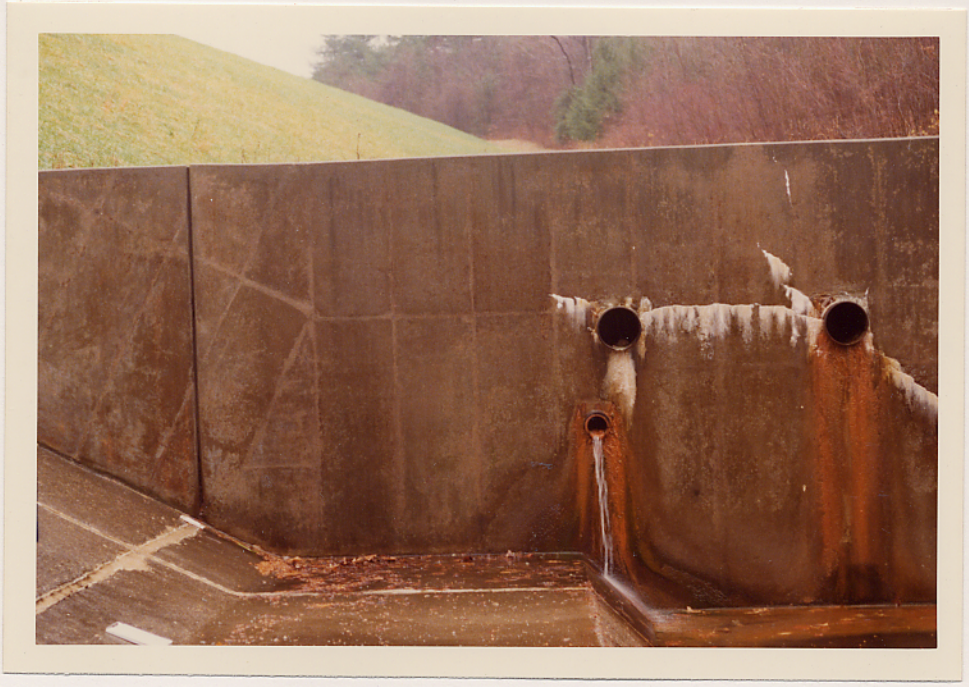


PHOTO NO. 10

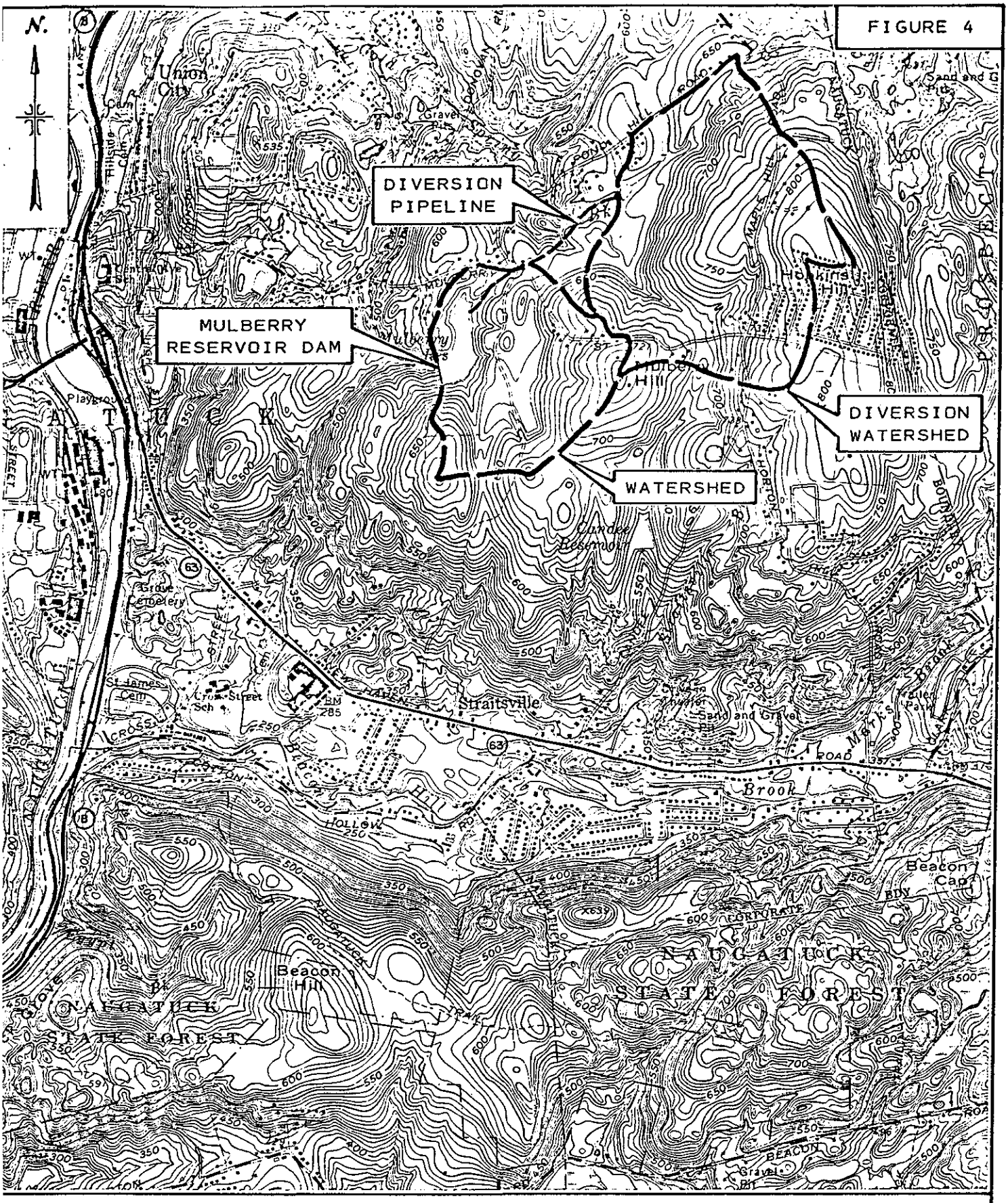
OUTLETS FOR TWO 12-INCH DIAMETER PIPES AND
DISCHARGE FROM 6-INCH DIAMETER TOE DRAIN

U.S.ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	MULBERRY RESERVOIR DAM TR. TO NAUGATUCK RIVER NAUGATUCK, CONNECTICUT CT 00130 DATE: 26 NOV '79
ROALD HAESTAD, INC. CONSULTING ENGINEERS WATERBURY, CONNECTICUT		

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

FIGURE 4



WATERSHED MAP

MULBERRY RESERVOIR DAM
NAUGATUCK, CONNECTICUT

SCALE: 1" = 2000'

ROALD HAESTAD, INC.

NAUGATUCK QUADRANGLE 1972

SUBJECT MULBERRY RES. DAM - PMF FLOOD ROUTING

WATERSHED AREA = 0.25 sq. mi.

TERRAIN IS ROLLING HILLS

MPF in cfs/sq. mi. for MINIMUM DRAINAGE AREA (2.0 sq. mi.)

MPF = 2150 cfs/sq. mi.

PMF = 2150 (0.25) = 537.5 cfs

Q_{p1} = 537.5 cfs

H_1 = 2.4' above spillway, From Discharge Curve

$STOR_1$ = 172 Ac-Ft., From Area Capacity Curve

= 12.9" runoff from 0.25 sq. mi.

$Q_{p2} = Q_{p1}\left(1 - \frac{STOR_1}{19}\right) = 537.5\left(1 - \frac{12.9}{19}\right) = 173$ cfs

$STOR_2$ = 155 Ac-Ft.

$STOR_{AVE.} = \frac{172 + 155}{2} = 164$ Ac-Ft.

H_3 = 1.9 Feet

Q_{p3} = 400 cfs

SPILLWAY CAPACITY = $CLH^{3/2}$

C = 3.55 L = 40' H = 5'

SPILLWAY CAPACITY = $3.55(40)(5)^{3/2}$ = 1587 cfs

USE 1600 cfs

% of PMF = $\frac{1600}{400} \times 100$ = 400% of PMF

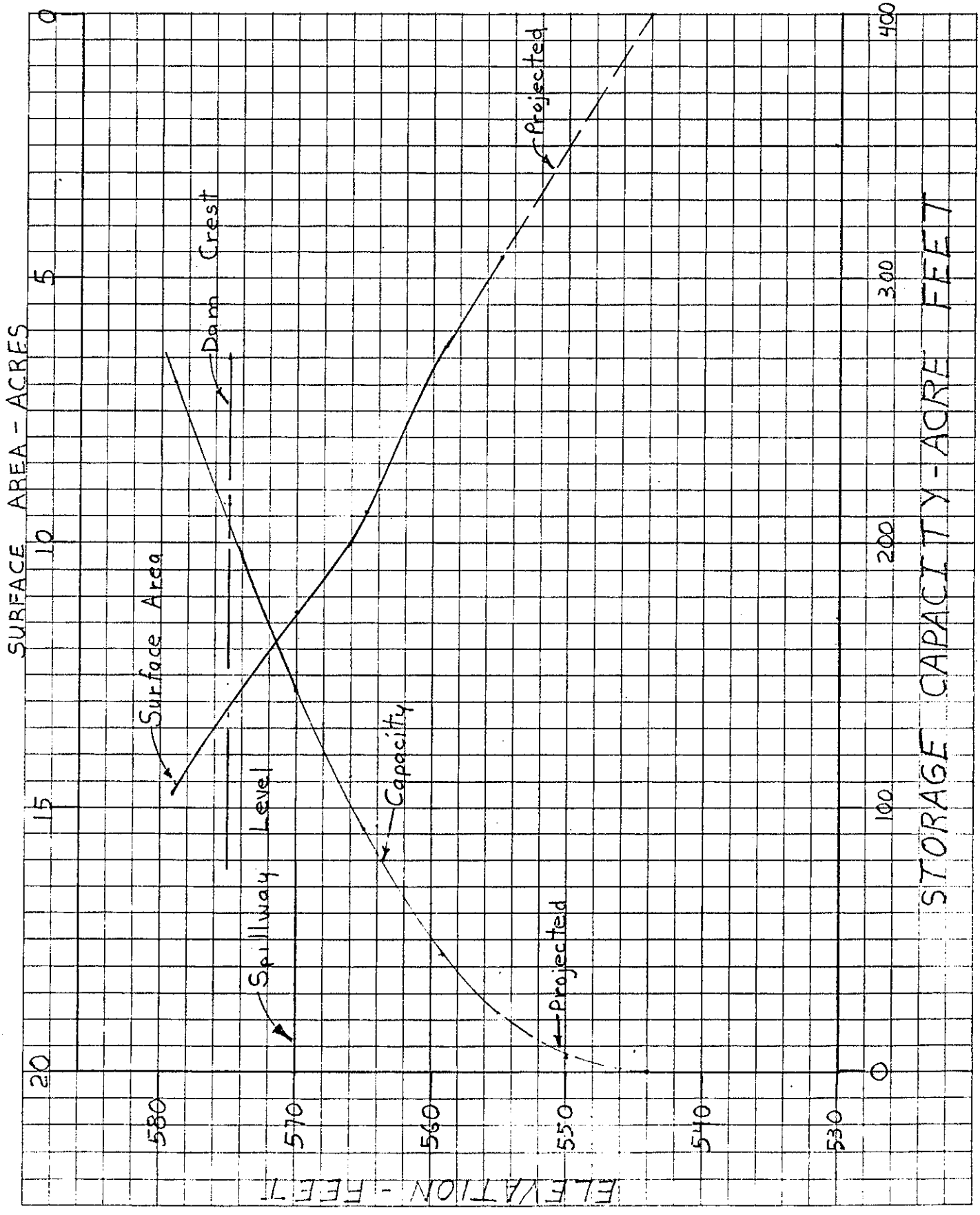
NOTE: CAPACITY OF DIVERSION PIPELINE IGNORED BECAUSE OF THE SMALL FLOW

BY SL DATE 12/4/79 **ROALD HAESTAD, INC.** SHEET NO 2 OF 12

CONSULTING ENGINEERS

CKD BY DLS DATE 12/8/79 37 Brookside Road - Waterbury, Conn. 06708 JOB NO 049-04

SUBJECT Mulberry Reservoir - Storage Capacity Curve

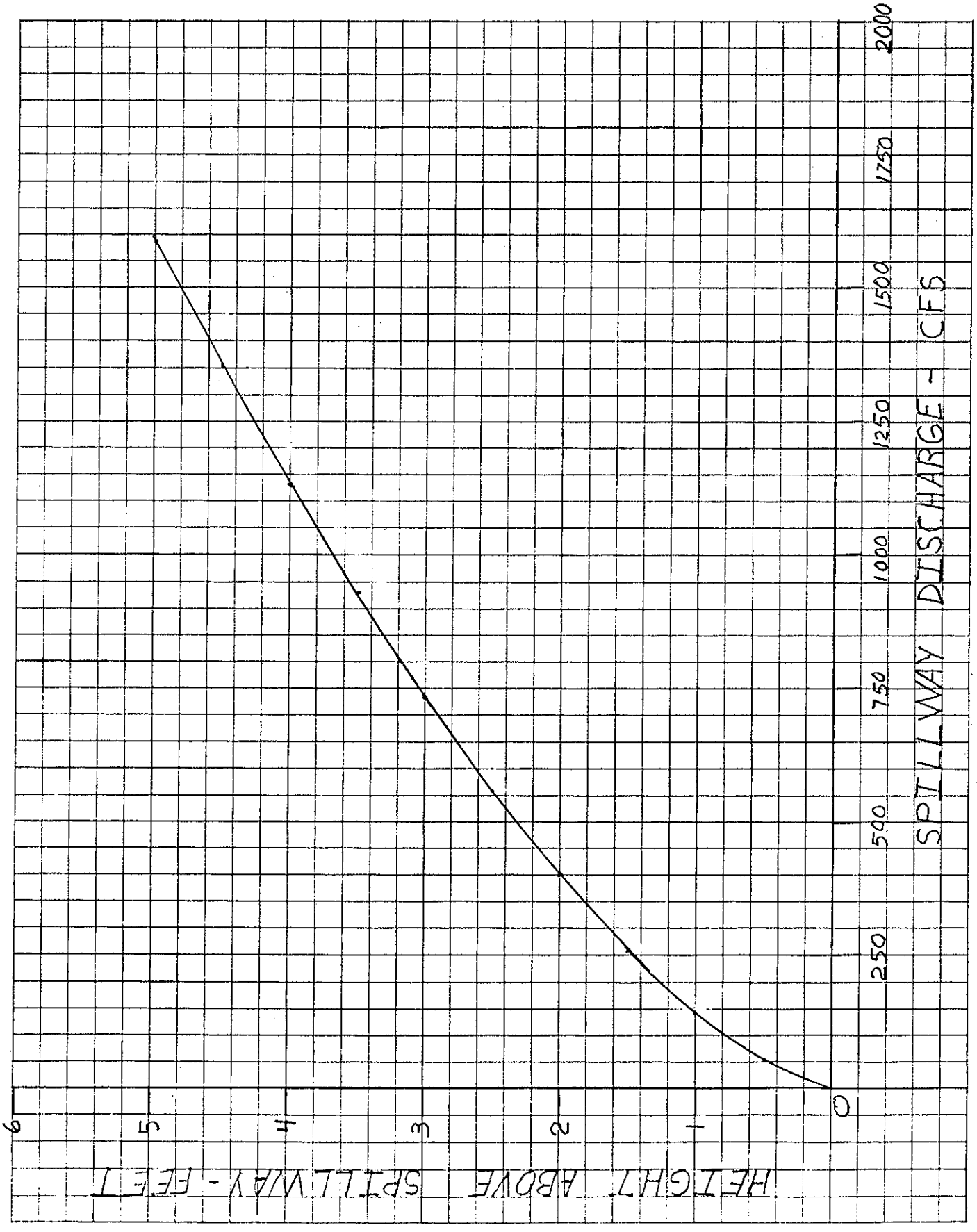


BY S.L. DATE 12/4/79. **ROALD HAESTAD, INC.** SHEET NO 3 OF 12

CONSULTING ENGINEERS

CKD BY D.H.S. DATE 12/6/79 37 Brookside Road - Waterbury, Conn. 06708 JOB NO 049-04

SUBJECT Mulberry Reservoir - Spillway Discharge Curve



DAM BREACH ANALYSIS

STORAGE AT PMF - 2' Above Spillway = 170 Ac-Ft. = S

$Q_{p1} = 8/27\ W_b \sqrt{g}\ Y_o^{3/2}$

W_b = BREACH WIDTH = 40% of Midheight of dam

$= 0.40\ (210') = 84'$

Y_o = Hydraulic Height of Dam = 63'

$Q_{p1} = 8/27\ (84)\ (\sqrt{32.2})\ (63)^{3/2} = 70,600$ cfs

---

SECTION 1 STAGE (H_1) at Section 1 = 28.5'

AREA (A_1) = 4400 ft.^{2} Length of Reach = 600'

Volume of Reach (V_1) = 4400 x 600 / 43560 = 60.6 Ac-Ft.

$Q_{p2\ TRIAL} = Q_{p1}\left(1 - \frac{V_1}{S}\right) = 70,600\left(1 - \frac{60.6}{170}\right) = 45,400$ cfs

$H_{2\ TRIAL} = 24.5'$ $A_{2\ TRIAL} = 3200$ ft.^{2}

$V_{2\ TRIAL} = 3200 \times 600 / 43560 = 44$ Ac-Ft.

$V_{AVE.} = \frac{V_1 + V_{2\ TRIAL}}{2} = \frac{60.6 + 44}{2} = 52.3$ Ac-Ft.

$Q_{p2} = 70,600\left(1 - \frac{52.3}{170}\right) = 48,900$ cfs

$H_2 = 25.5'$ $A_2 = 3400$ ft.^{2}

SECTION 2

$Q_{p2} = 48,900$ cfs REACH LENGTH = 900 ft.

$H_1 = 22.2$ ft. $A_1 = 3800$ ft.^{2}

$V = \frac{3400 + 3800}{2} \times 900/43560 = 74$ Ac-Ft.

$Q_{p3\ TRIAL} = 48,900\left(1 - \frac{74}{170}\right) = 27,600$ cfs

$H_{2\ TRIAL} = 17.5'$ $A_{2\ TRIAL} = 2600$ ft.^{2}

$V_{2\ TRIAL} = \frac{3400 + 2600}{2} \times 900/43560 = 62$ Ac-Ft.

$V_{AVE} = \frac{74 + 62}{2} = 68$ Ac-Ft.

$Q_{p3} = 48,900\left(1 - \frac{68}{170}\right) = 29,300$ cfs

$H_2 = 18'$ $A_2 = 2700$ ft.^{2}

SECTION 3 $Q_{p3} = 29,300$ cfs Reach Length = 1400'

$H_1 = 23$ ft. $A_1 = 2100$ ft^2

$V_1 = \frac{2700 + 2100}{2} \times 1400/43560 = 77$ Ac-Ft.

$Q_{p4\ TRIAL} = 29,300\left(1 - \frac{77}{170}\right) = 16,000$ cfs

$H_{2\ TRIAL} = 17.8'$ $A_{2\ TRIAL} = 1300$ ft.^{2}

$V_{2\ TRIAL} = \frac{2700 + 1300}{2}(1400)/43560 = 64$ Ac-Ft.

$V_{AVE} = \frac{64 + 77}{2} = 70.5$ Ac-Ft.

$Q_{p4} = 29,300\left(1 - \frac{70.5}{170}\right) = 17,150$ cfs

$H_2 = 18.5'$ $A_2 = 1400$ ft.^{2}

SECTION 4 $Q_{p4} = 17,150$ cfs REACH LENGTH = 1300'

$H_1 = 19'$ $A_1 = 950$ ft.^{2}

$V_1 = \frac{1400+950}{2} \times 1300/43560 = 35$ Ac-Ft.

$Q_{p5\ TRIAL} = 17,150\left(1-\frac{35}{170}\right) = 13,600$ cfs

$H_{2T} = 17.0'$ $A_{2T} = 700$ ft.^{2}

$V_{2\ TRIAL} = \frac{1400+700}{2} \times 1300/43560 = 31$ Ac-Ft.

$V_{AVE} = \frac{35+31}{2} = 33$ Ac-Ft.

$Q_{p5} = 17,150\left(1-\frac{33}{170}\right) = 13,800$ cfs

$H_2 = 17.0'$ $A_2 = 700$ ft.^{2}

SECTION 5 $Q_{p5} = 13,800$ cfs REACH LENGTH = 750'

$H_1 = 8.1'$ $A_1 = 1,200$ ft.^{2}

$V_1 = \frac{700+1,200}{2} \times 750/43560 = 16.35$ use 16 ac-ft

$Q_{p6\ TRIAL} = 13,800\left(1-\frac{16}{170}\right) = 12,500$ cfs

$H_{2\ TRIAL} = 7.9'$ $A_{2\ TRIAL} = 1,150$ ft.^{2}

$V_{2\ TRIAL} = \frac{700+1,150}{2} \times 750/43560 = 15.92$ use 16 ac-ft

$V_{AVE} = \frac{16+16}{2} = 16$ Ac-Ft.

$Q_{p6} = 13,800\left(1-\frac{16}{170}\right) = 12,500$ cfs

$H_2 = 7.9'$ $A_2 = 1,150$ ft.^{2}

The flow line will be approximately 8 feet above the bottom of the channel.

SECTION NO 6:

Planimeter Readings:

Contour 230:	Third	= 3.49	sq. in	0.25
	First	= 2.99	sq in	0.26
	Start	= 2.73	sq in	
Contour 240:	Third	= 4.12	sq in	0.95
	First	= 2.23	sq in	0.96
	Start	= 1.27	sq in	

$$\text{Storage Capacity} = \left[\left(\frac{0.25+0}{2}\right) in^2 \times \frac{2.5\times10^5\ ft^2}{in^2} \times 10\ ft\right] + \left[\left(\frac{0.95+0.25}{2}\right) \times \frac{2.5\times10^5 ft^2}{in^2} \times 10\ ft\right]$$

$$= 3.25\times10^5\ ft^3 + 1.5\times10^6\ ft^3$$

$$= 1{,}825{,}000\ ft^3 \times \frac{1\ acre\text{-}ft}{43{,}560\ ft^3} = 42\ acre\text{-}ft$$

$Q_{P6} = 12{,}500$ cfs Reach Length = 900 ft

$V_1 = 42$ ac-ft

$Q_{P7} = Q_{P6}(1 - V_1/S)$

$Q_{P7} = 12{,}500\ cfs\ (1 - 42/170) = 9{,}410$ cfs

BY DLS DATE 11-17-79 **ROALD HAESTAD, INC.** SHEET NO 8 OF 12

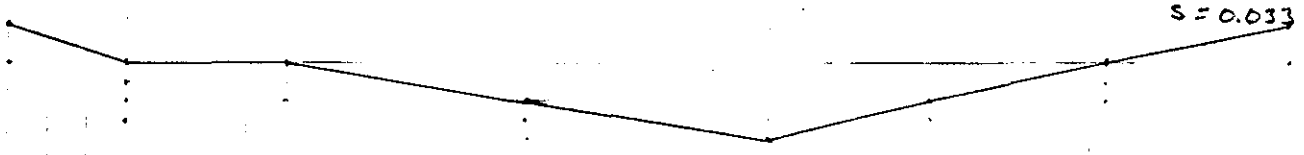
CONSULTING ENGINEERS

CKD BY WSH DATE 12/17/79 37 Brookside Road - Waterbury, Conn. 06708 JOB NO 049-04

SUBJECT MULBERRY RES. DAM - FLOOD ROUTING

Section 1

Scale: 1"=50'
L = 600'
n = 0.10
S = 0.033



D (ft.)	WP (ft)	A (ft²)	R (ft)	S (ft/ft)	V (fps)	Q (cfs)
5	50	125	2.50	0.033	5.0	625
10	100	500	5.00	0.033	7.9	3950
15	150	1140	7.60	0.033	10.4	11,856
20	205	2050	10.00	0.033	12.5	25,625
25	295	3390	11.49	0.033	13.8	46,782
30	330	4900	14.85	0.033	16.3	79,870

SECTION 2

SCALE: 1"=100'

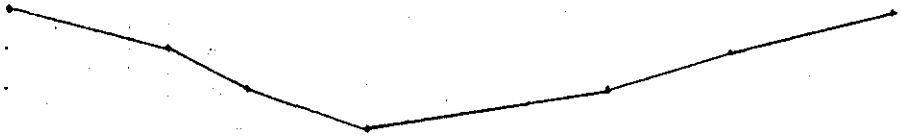
n = 0.10
L = 900'
S = 0.024

D (ft)	WP (ft)	A (ft²)	R (ft)	S (ft/ft)	V (fps)	Q (cfs)
5	80	440	5.50	0.024	7.2	3168
10	160	1100	6.88	0.024	8.3	9130
15	210	2000	9.52	0.024	10.3	20,600
20	260	3150	12.12	0.024	12.2	38,430
25	310	4550	14.68	0.024	13.8	62,790
30	360	6225	17.29	0.024	15.4	95,865

SUBJECT MULBERRY RES. DAM - FLOOD ROUTING

SECTION 3

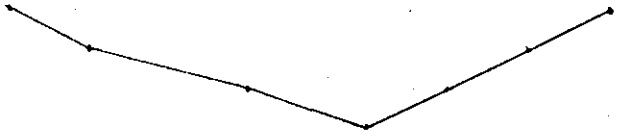
SCALE: 1"=50'
L = 1400
n = 0.10
S = 0.034



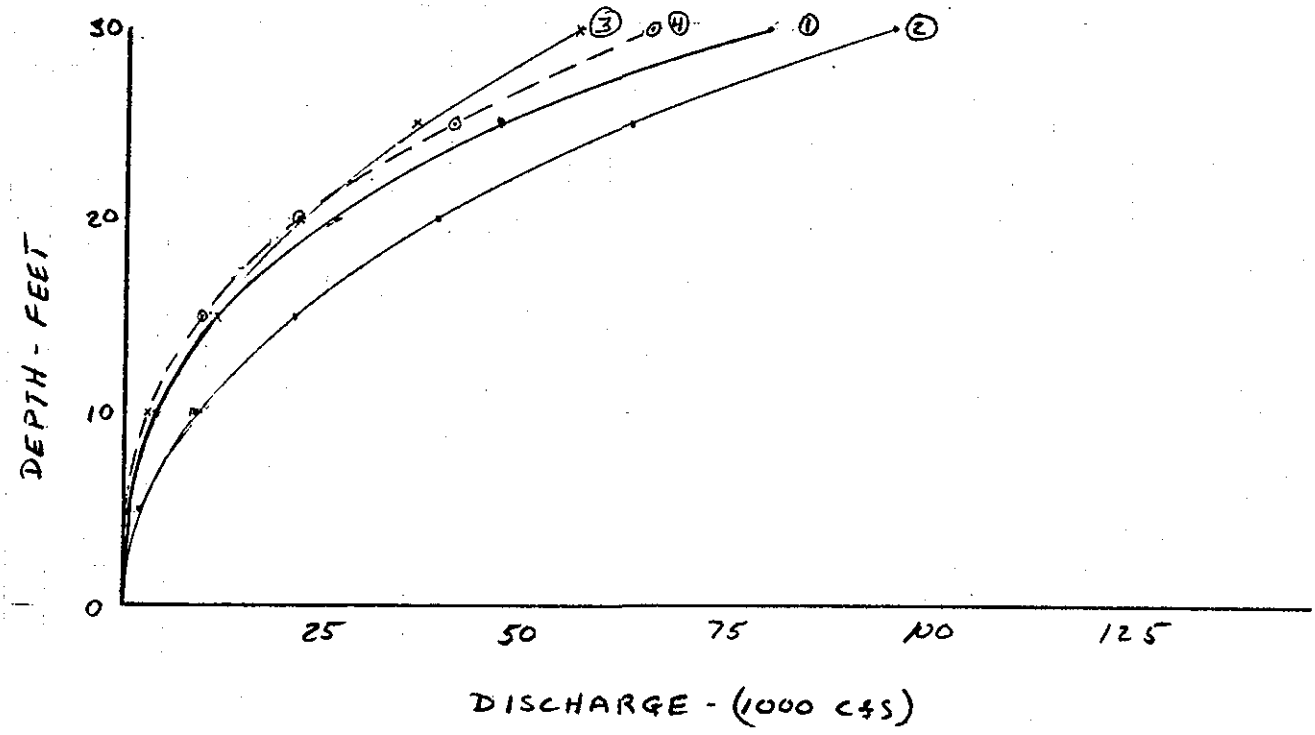
D	WP	A	R	S	V	Q
5	50	110	2.20	0.034	4.6	506
10	95	450	4.74	0.034	7.7	3465
15	120	1025	8.54	0.034	11.5	11,788
20	150	1600	10.67	0.034	13.3	21,280
25	190	2400	12.63	0.034	14.9	35,760
30	230	3400	14.78	0.034	16.5	56,100

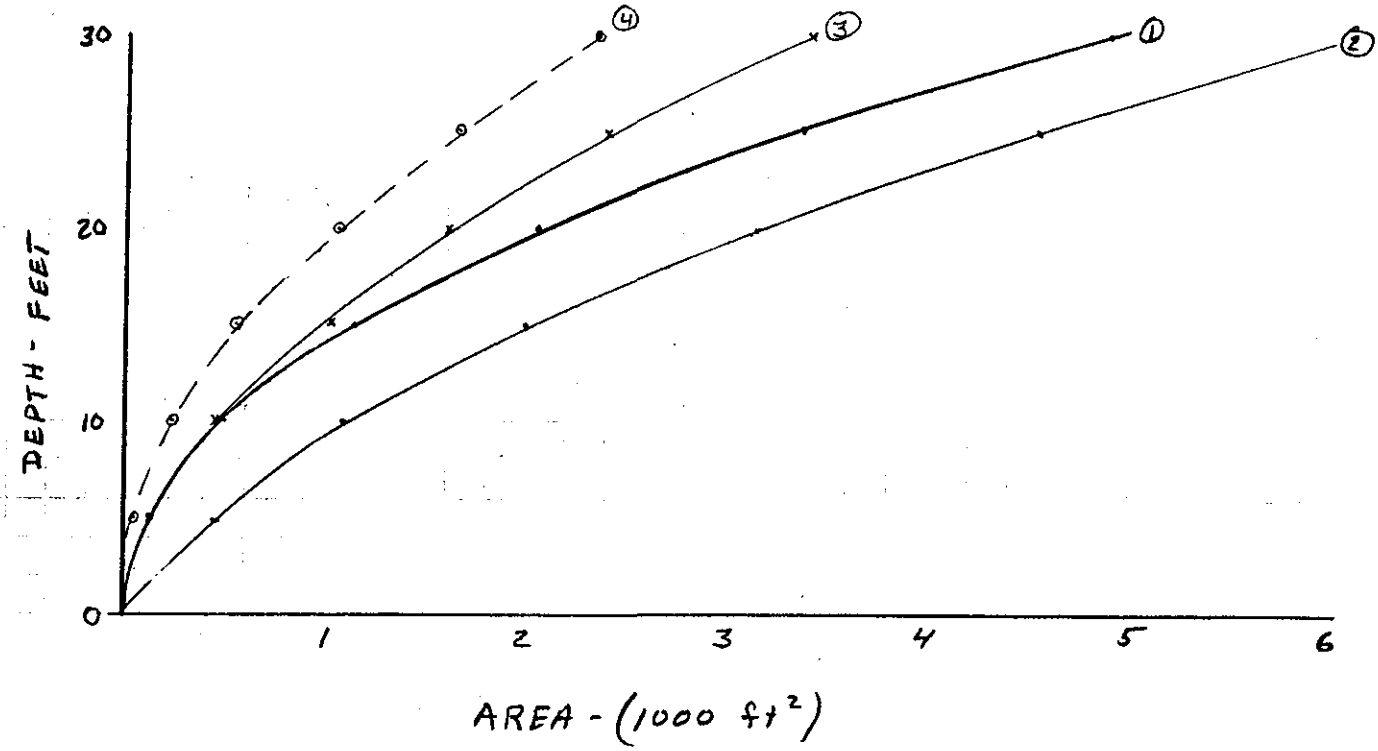
SECTION 4

Scale: 1"=50'
L = 1300
n = 0.10
S = 0.100



D	WP	A	R	S	V	Q
5	30	65	2.17	0.100	7.9	514
10	55	250	4.55	0.100	12.9	3225
15	85	575	6.76	0.100	16.9	9718
20	115	1050	9.13	0.100	20.5	21,525
25	140	1650	11.79	0.100	24.4	40,260
30	165	2350	14.24	0.100	27.6	64,860

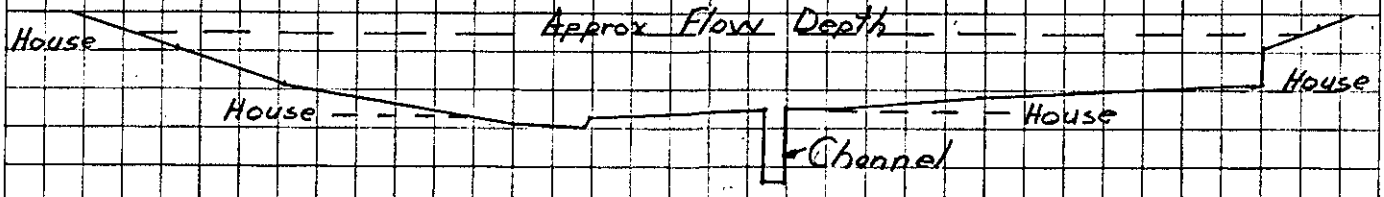

30
20
10
0
DEPTH - FEET
25
50
75
100
125
DISCHARGE - (1000 CFS)
1
2
3
4


30
20
10
0
DEPTH - FEET
1
2
3
4
5
6
AREA - (1000 ft²)
1
2
3
4

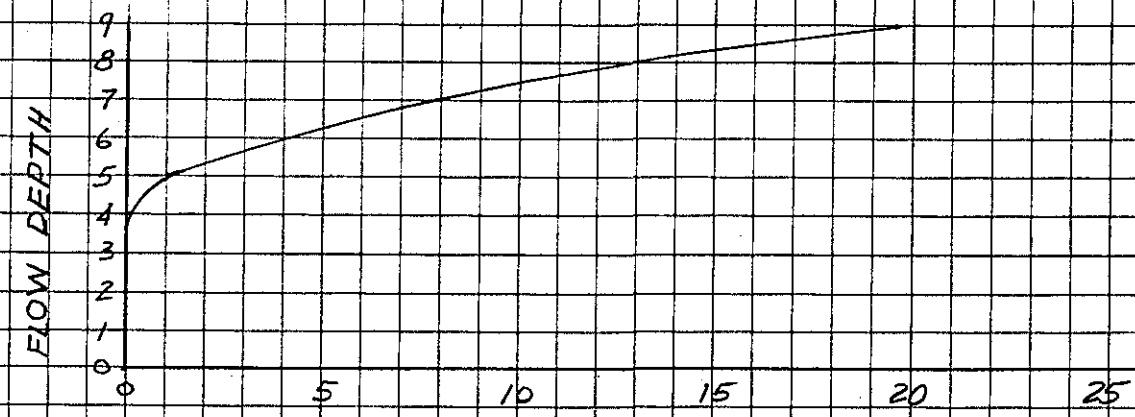
SUBJECT MULBERRY - Flood Routing

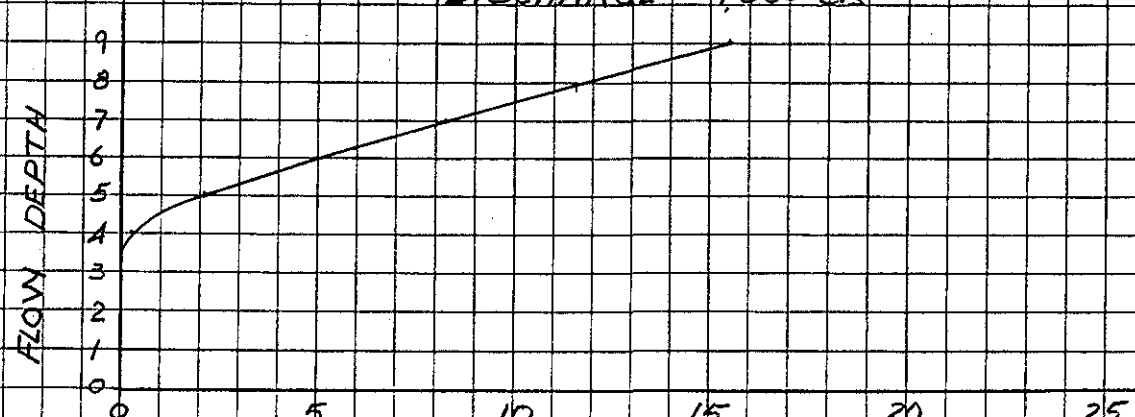
SECTION NO 5 (Field Surveyed) Scale 1" = 60' Horiz
1" = 10' Vert

L = 750 ft n = 0.05 s = 0.023



D	W_P	A	R	S	V	Q
4	45	30	0.67	0.023	3.46	104
5	185	211	1.14	0.023	4.93	1040
7	267	825	3.09	0.023	9.59	7,912
9	334	1,556	4.66	0.023	12.61	19,621





SECTION NO 6:

At a culvert consisting of a 36" metal pipe 7 ft long emptying into a stone arch culvert 4' wide by 5' high. The headwall is constructed of stone masonry.

Use Chart #2 in Hydraulic Charts for the Selection of Highway Culverts.

Height of Water Above Invert (ft)	HW/D (ft/ft)	Q (cfs)
0	0	0
1	0.3	5
2	0.7	20
3	1	35
6	2	70
9	3	90
12	4	110
15	5	125
18	6	140
21	7	150

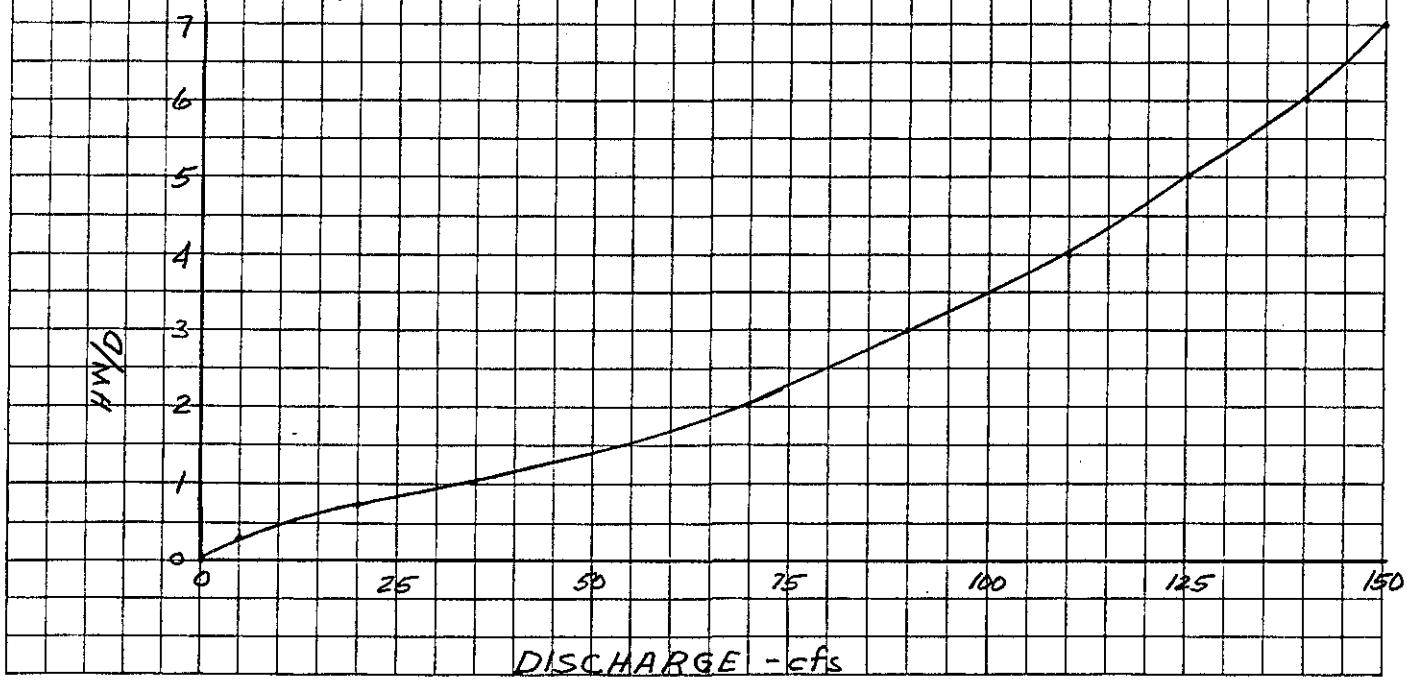
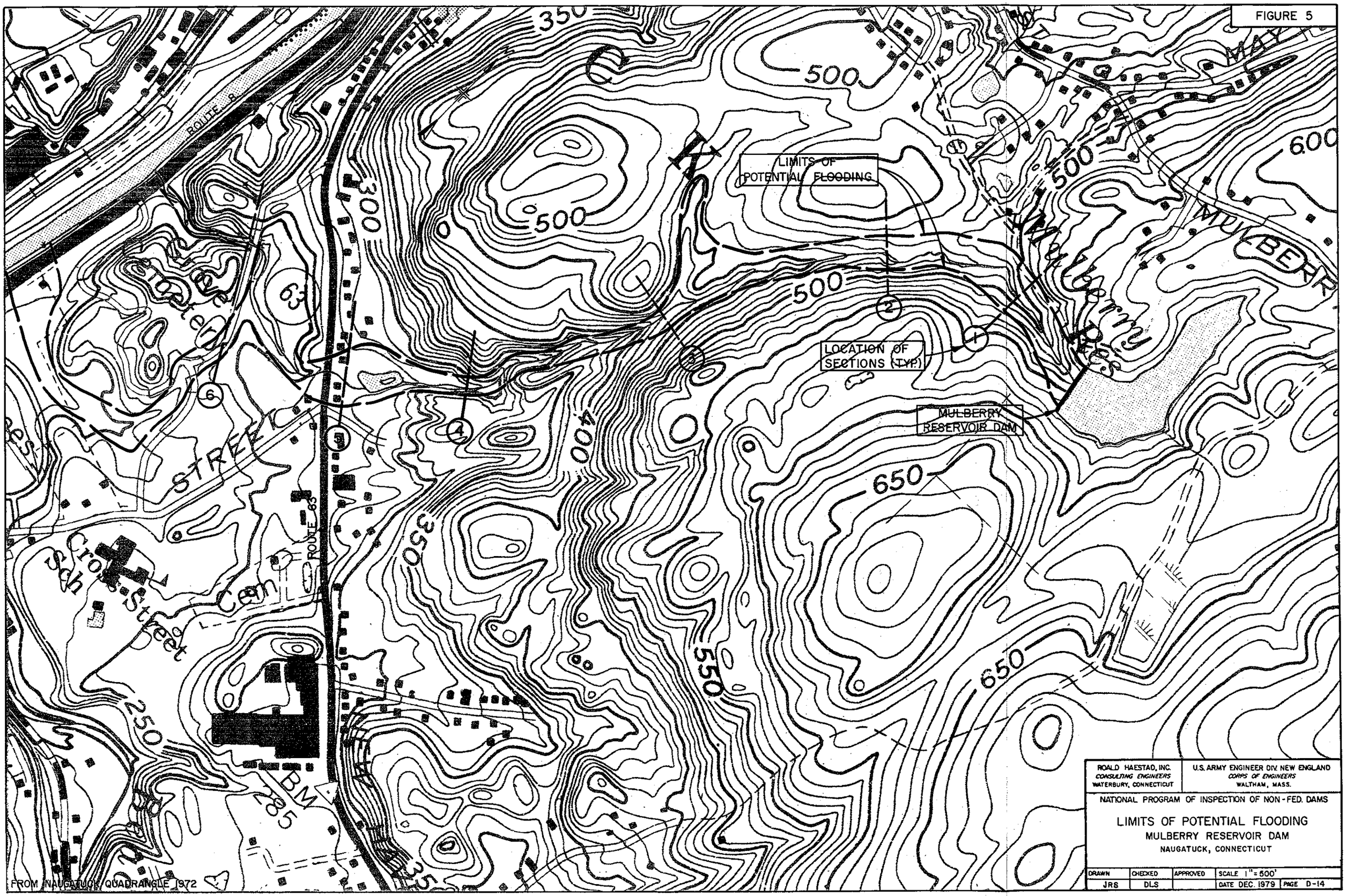


FIGURE 5



ROALD HAESTAD, INC. *CONSULTING ENGINEERS* WATERBURY, CONNECTICUT	U.S. ARMY ENGINEER DIV NEW ENGLAND *CORPS OF ENGINEERS* WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LIMITS OF POTENTIAL FLOODING
MULBERRY RESERVOIR DAM
NAUGATUCK, CONNECTICUT

DRAWN	CHECKED	APPROVED	SCALE 1"=500'
JRS	DLS		DATE DEC. 1979 PAGE D-14